WHITE RIVER SHALE PROJECT

Detailed Development Plan • Oil Shale Tracts Ua and Ub • Volume II • 1980

FINAL DRAFT

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Section 4: Planned Environmental Protection Procedures
Section 5: Environmental Effects of Proposed Action After Mitigation
Section 6: Monitoring Program
Section 7: Alternatives and Selection Rationale

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Bio-Resources Inc.
Phillips Petroleum Company
Sohio Petroleum Company
Sunoco Energy Development Co.
The Cleveland-Cliffs Iron Company
Utah State University
VTN Consolidated, Inc.

Each entity has contributed significantly in its own area of specialization, and each deserves credit for technical content. The cooperation and hard work of all parties is sincerely appreciated.

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Section 4

PLANNED ENVIRONMENTAL PROTECTION PROCEDURES

4.1 INTRODUCTION

Section 4 contains the plans and procedures proposed to reduce and mitigate the environmental impacts of the project. It includes more detailed descriptions of pollution control systems introduced in Section 3, plans to rehabilitate, preserve, or manage environmental resources, plans for the prevention or control of fire, accidental spills, and hazards to public health and safety. These plans and procedures are assumed to be implemented in the analysis of environmental impacts presented in Section 5, "Environmental Effects of the Proposed Action After Mitigation." For the purposes of this report, including assessment of potential impacts on the environment, Phase I has been considered to include one direct-heat retort (Paraho) and one indirect-heat retort (Union B). Phase II includes one Union B, one Tosco II (for fines), and six Paraho retorts. Phase III includes one Union B, two Tosco II, and twelve Paraho retorts. Emission factors and subsequent impact assessments have been based on this mix of retorts.

Specific aspects of environmental protection addressed in this section include:

- Air pollution control
- Solid waste disposal
- Water pollution control
- Water drainage and erosion control
- Surface rehabilitation and revegetation

- Fish and wildlife management
- Protection of historic, prehistoric, and paleontological resources
- Aesthetic values
- Fire prevention and control
- Oil and hazardous materials spills
- Prevention of hazards to public health and safety

4.2 AIR POLLUTION CONTROL

4.2.1 REGULATIONS, STANDARDS, AND GUIDELINES

The regulations and guidelines pertaining to air pollution control for this project include regulations arising from the Clean Air Act as amended (42 USC 1857 et seq.) and the Utah Air Conservation Regulations adopted September 26, 1971 and revised February 1980. Pertinent regulations authorized by the Clean Air Act and its amendments include: National Primary and Secondary Ambient Air Quality Standards (40 CFR 50), Prevention of Significant Deterioration Regulations (40 CFR 51, 52, and 124), Standards of Performance for New Stationary Sources (40 CFR 60), and National Emission Standards for Hazardous Air Pollutants (40 CFR 61). In general, the project must comply with both emission and ambient air quality standards.

The primary concerns applicable to construction activities (see Section 4.2.3.1) are those associated with open burning, fugitive dust, and vehicular emissions. All vehicles used during the construction period will meet the pertinent emission standards. In addition, appropriate measures will be taken to keep construction dust and open burning at a minimum.

During all operating stages of the project, it is intended that all plant emissions will be within the limits allowed by the Federal New Source Performance Standards (NSPS) and the National Emission Standards for Hazardous Air Pollutants (NESHAP). NSPS are given in Table 4.2-1. NESHAP limit emissions and in some cases prohibit the use of asbestos, beryllium, mercury, and vinyl chloride. Emissions of hazardous pollutants, if any, will meet NESHAP.

Regulations controlling the levels of pollutants in the ambient atmosphere include federal and Utah state standards, which are identical. Pertinent ambient air quality standards are listed in Table 4.2-2; however, these standards are reviewed by the EPA from time to time and are subject to change.

Table 4.2-1

FEDERAL NEW SOURCE PERFORMANCE STANDARDS

Type of Emission	Emission Limits		
	Fossil-Fuel Fired Boilers	Refineries	Petroleum Storage Vessels
Particulate Matter	0.10 lb/MMBtu; 20% opacity except for one 6-minute period per hour of not more than 27% opacity	1.0 lb/1,000 lb of coke burn-off in the catalyst regenerator except 0.1 lb/MMBtu from use of fossil fuel; 30% opacity except for one 6-minute average in any 1 hour	N/A
Sulfur Dioxide	(a) Liquid Fuel 0.80 lb/MMBtu (b) Solid Fuel 1.2 lb/MMBtu	0.1 gr/dscf H_2S in fuel gas or equivalent treatment of exhaust gas. For Claus sulfur plants, 0.025% by volume of SO_2 at 0% O_2 on a dry basis if control by oxidation or reduction and incineration; if reduction not followed by incineration, 0.03% S and 0.001% H_2S as SO_2	N/A
Nitrogen Oxides	(a) Gaseous Fuel 0.20 lb/MMBtu expressed as NO_2 (b) Liquid Fuel 0.50 lb/MMBtu expressed as NO_2 (c) Solid Fuel (except lignite) 0.70 lb/MMBtu expressed as NO_2	N/A	N/A
Carbon Monoxide	N/A	0.050% by volume from cat cracking unit	N/A
Volatile Organic Compounds	N/A	N/A	(a) If the true vapor pressure of the petroleum liquid, as stored, is equal to or greater than 78 mm Hg (1.5 psia) but not greater than 570 mm Hg (11.1 psia), the storage vessel must be equipped with a floating roof and double-seal closure device, a fixed roof with an internal floating type cover and closure device, a vapor recovery system and a vapor return or disposal system which is designed to reduce volatile organic compounds emissions by at least 95 percent by weight, or an equivalent system. (b) If the true vapor pressure of the petroleum liquid, as stored, is greater than 570 mm Hg (11.1 psia), the storage vessel must be equipped with a vapor recovery system and a vapor return or disposal system which is designed to reduce volatile organic compounds by at least 95 percent by weight. (c) There are no regulations covering storage vessels for petroleum liquids with true vapor pressures under 78 mm Hg (1.5 psia).

Table 4.2-2

FEDERAL AMBIENT AIR QUALITY STANDARDS
(Same as Utah Standards)

Pollutant	Averaging Time	National Standards[a]		
		Primary[b,c]	Secondary[d]	Method of Measurement[e]
Ozone	1 hour	235 ug/m^3 (0.12 ppm)	Same as primary standards	UV absorbtion
Carbon Monoxide	8 hours	10 mg/m^3 (9 ppm)	Same as primary standards	Nondispersive infrared spectroscopy
	1 hour	40 mg/m^3 (35 ppm)		
Nitrogen Dioxide	Annual Average	100 ug/m^3 (0.05 ppm)	Same as primary standards	Chemiluminescent
Sulfur Dioxide	Annual Average	80 ug/m^3 (0.03 ppm)	-	Pararosaniline
	24 hours	365 ug/m^3 (0.14 ppm)	-	
	3 hours	-	1,300 ug/m^3 (0.05 ppm)	
Suspended Particulate Matter	Annual geometric mean	75 ug/m^3	60 ug/m^3	High-volume sampling
	24 hours	260 ug/m^3	150 ug/m^3	
Hydrocarbons[f] (corrected for methane)	3 hours (6-9 a.m.)	160 ug/m^3 (0.24 ppm)	Same as primary standards	Flame ionization detection using gas chromatography
Lead	Maximum arithmetic mean averaged over a calendar quarter	1.5 ug/m^3	Same as primary standards	Atomic absorption spectrometry

(a) National standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once per year.

(b) Concentration expressed first in units in which it was promulgated. Equivalent units given in parentheses are based upon a reference temperature of 25C and a reference pressure of 760 mm of mercury. All measurements of air quality are to be corrected to a reference temperature of 25C and a reference pressure of 760 mm of Hg (1,013.2 millibar); ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.

(c) National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than 3 years after that state's implementation plan is approved by the Environmental Protection Agency (EPA).

(d) National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after its implementation plan is approved by the EPA.

(e) Reference method as described by the EPA. An "equivalent method" of measurement may be used but must have a "consistent relationship to the reference method" to be approved by the EPA.

(f) This is a guideline for control of ozone.

Recently, the EPA said that the 1-hour carbon monoxide standard may be reduced from 40 mg/m^3 to 29 mg/m^3 (35 ppm to 25 ppm). It is also likely that a 1-hour standard for nitrogen dioxide of 470 to 960 $\mu g/m^3$ will be adopted in the near future. The standards for particulate matter and sulfur dioxide are presently being reviewed, but it appears these standards will remain unchanged.

Pursuant to the Clean Air Act, the EPA has promulgated regulations to prevent "significant deterioration" (PSD) of air quality in areas already cleaner than Federal Secondary Standards require. Presently, these regulations emphasize particulate matter and sulfur dioxide but control other pollutants as well. Table 4.2-3 summarizes the existing EPA regulations for allowable increments of SO_2 and particulates in the three proposed regional classifications. The project area is designated as a PSD Class II area, but the potential impact on any nearby Class I areas must be assessed. Also, allowable increments for other pollutants could be promulgated in the future.

In addition to regulating numerous pollutants, EPA has the authority to protect visibility in Class I areas. Visibility protection regulations were proposed on May 22, 1980 (40 CFR 51). Final regulations could be promulgated as early as November 1980. The proposed regulations suggest that visibility considerations could impose restrictions even more stringent than allowable PSD increments if any Class I areas are within 200 kilometers of the project.

4.2.2 AIR POLLUTANT EMISSION INVENTORY

Tables 4.2-4 and 4.2-5 list the expected emissions from Phase I and Phase III, respectively. (Phase II is not tabulated because its emissions will be about one-half of those of Phase III.) The tables also show estimated stack heights, diameters, temperatures, and volume flows. Emission rates are rough estimates and are conservative. As plant design progresses, emission data may need to be revised with appropriate changes in preconstruction permit limits.

Table 4.2-3

LIMITS OF SIGNIFICANT DETERIORATION OF AIR QUALITY

Pollutant	Area Designations[a,b]		
	Class I ($\mu g/m^3$)	Class II ($\mu g/m^3$)	Class III ($\mu g/m^3$)
Particulate Matter:			
Annual geometric mean	5	19	37
24-hour maximum	10	37	75
Sulfur Dioxide:			
Annual arithmetic mean	2	20	40
24-hour maximum	5	91	182
3-hour maximum	25	512	700

(a) Class I applies to areas in which practically any change in air quality is considered significant; Class II applies to areas in which deterioration normally accompanying moderate, well-controlled growth is considered insignificant; and Class III applies to those areas in which deterioration accompanying large industrial growth is considered insignificant.

(b) Areas designated as Class I, Class II, or Class III are limited to the above increases in pollutant concentrations over baseline air quality concentration or to pollutant concentrations no greater than the National Ambient Air Quality Standards, whichever is less.

It should be noted that many of the emission rate estimates included in the source inventory have been based on emissions from similar types of sources. This has been necessary because many of the operations included in this project are new, and source data are simply not available. It should further be noted that estimates of project emissions will be improved as the project progresses through Phases I, II, and III.

A number of flare stacks have been provided to vent and burn combustible gases during startup, shutdown, maintenance, and upset conditions. It is expected that each of these flare stacks will be approximately 150 feet high and of smokeless design. The flare stacks and expected emissions to the atmosphere have not been included in the source inventories (Tables 4.2-4 and 4.2-5). Because the flares are standby safety devices, they will be inoperative during normal plant operations.

4.2.3 AIR POLLUTION CONTROL PLAN

4.2.3.1 Construction Phase

Construction in all phases of the project will generate dust. Plans for controlling dust and for complying with open-burning regulations and with PSD requirements are described in the following paragraphs.

Dust Control. The primary air pollutant will be fugitive dust from traffic, blasting, grading, and other construction-related activities. For PSD purposes, Best Available Control Technology (BACT) is required. To control and minimize air pollution, and to comply with BACT requirements, the following procedures will be established and practiced during construction activities on the site.

- All areas to be blasted will be minimized and overshooting will be prevented.
- All parking lots will be paved, oiled, or graveled. All private vehicles will be restricted to authorized parking areas only, and private vehicular traffic at the construction site will be limited.

Table 4.2-4

AIR POLLUTANT EMISSION INVENTORY
PHASE I

Act	f n	Number of Exhaust Points	Exhaust Point Diameter	Exhaust Gas Temperature	Exhaust Volume
Minin		One	28 ft	Ambient	2,000,000 SCFM
Blast		One	28 ft	Ambient	2,000,000 SCFM
Prima Crush		One	28 ft	Ambient	2,000,000 SCFM
In-mi Trans		One	28 ft	Ambient	2,000,000 SCFM
Mine Equip		One	28 ft	Ambient	2,000,000 SCFM
Surfa Trans Point		Thirteen	1.46 ft	Ambient	5,000 SCFM each
Coars Stora		One	3.6 acres	Ambient	—
Secon Crush Scree		Two	1.93 ft	Ambient	10,000 SCFM each
Fine Stora		One	26 acres	Ambient	—
Direc Verti Retor		One	1.93 ft	Ambient	10,000 SCFM
Indir Verti Retor		One	1.93 ft	Ambient	10,000 SCFM
Direc Proce Shale Moist		One	3 ft	100F	1,000 SCFM

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Table 4.2-4

AIR POLLUTANT EMISSION INVENTORY
PHASE I

Activity	Material Handled	Pollutant	Emission Factor w/o Control	Total Expected Emissions w/o Control	Control Measure and Efficiency	Total Expected Emissions w/ Control	Height of Emission Point	Number of Exhaust Points	Exhaust Point Diameter	Exhaust Gas Temperature	Exhaust Volume
Mining	Up to 30,000 tons shale/day	Partic.	0.009 lb/hr-ton[a]	6,480 lb/day	Wet suppression & baffled settling chamber (98.5%)	97 lb/day	Surface	One	28 ft	Ambient	2,000,000 SCFM
Blasting	Up to 18,000 lb ANFO/day	Partic.	0.01 lb/ton shale[b]	300 lb/day	Wet suppression & baffled settling chamber (98.5%)	5 lb/day	Surface	One	28 ft	Ambient	2,000,000 SCFM
		CO	0.0211 lb/lb ANFO[b]	380 lb/day	None	380 lb/day					
		NO_x	0.0016 lb/lb ANFO[b]	29 lb/day	None	29 lb/day	Surface				
Primary Crushing	Up to 15,000 tons shale/day	Partic.	0.02 lb/ton[c]	300 lb/day	Same as above	5 lb/day	Surface	One	28 ft	Ambient	2,000,000 SCFM
In-mine Transfer (8)	Up to 30,000 tons shale/day	Partic.	0.004 lb/ton[i] transfer point	960 lb/day	Same as above	14 lb/day	Surface	One	28 ft	Ambient	2,000,000 SCFM
Mine Mobile Equipment	5,000 gal/day diesel fuel (13,000 hp)	Partic.	22 lb/1,000 gal[e]	110 lb/day	None	110 lb/day	Surface	One	28 ft	Ambient	2,000,000 SCFM
		CO	90 lb/1,000 gal	450 lb/day		450 lb/day					
		HC	28 lb/1,000 gal	140 lb/day		140 lb/day					
		NO_x	428 lb/1,000 gal	2,140 lb/day		2,140 lb/day					
		SO_2	31 lb/1,000 gal	155 lb/day		155 lb/day					
Surface Transfer Points (20)	Up to 28,100 tons shale/day	Partic	0.004 lb/ton[i] transfer point	2,250 lb/day	Venturi scrubber[e] (99.5%)	11 lb/day	50 ft	Thirteen	1.46 ft	Ambient	5,000 SCFM each
Coarse Shale Storage Pile	810 ton/day 400,000 tons total on 3.6 acres	Partic.	0.04 lb/ton load-in[d]	32 lb/day	Flexible chute (75%)[f]	8 lb/day	Surface	One	3.6 acres	Ambient	—
			0.02 lb/ton-yr maintenance	22 lb/day	None	22 lb/day					
			0.018 lb/ton-yr wind erosion	20 lb/day	None	20 lb/day					
Secondary Crushing and Screening	Up to 28,100 tons shale/day	Partic	0.6 lb/ton[j]	16,860 lb/day	Venturi scrubber[e] (99.5%)	85 lb/day	50 ft	Two	1.93 ft	Ambient	10,000 SCFM each
Fine Shale Storage	Up to 2,600 tons shale/day (1,300,000 tons avg. in pile)	Partic.	0.04 lb/ton load-in[d]	104 lb/day	Flexible chute (75%)[f]	26 lb/day	Surface	One	26 acres	Ambient	
			0.02 lb/ton-yr maintenance	71 lb/day	None	71 lb/day					
			0.018 lb/ton-yr wind erosion	64 lb/day	None	64 lb/day					
Direct Heat Vertical-Type Retort	Up to 13,600 tons shale/day	Partic.	0.004 lb/ton[i]	54 lb/day	Baghouse (99.5%)[e]	1 lb/day	50 ft	One	1.93 ft	Ambient	10,000 SCFM
Indirect Heat Vertical-Type Retort	Up to 11,600 tons shale/day	Partic.	0.004 lb/ton[i]	46 lb/day	Baghouse (99.5%)[e]	1 lb/day	50 ft	One	1.93 ft	Ambient	10,000 SCFM
Direct Heat Processed Shale Moisturizer	Up to 11,200 tons shale/day	Partic	0.004 lb/ton(i)	45 lb/day	Wet suppresion (90%)[f]	5 lb/day	Surface	One	3 ft	100F	1,000 SCFM

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Activity	Material Handled	Pollutant	Emission Factor w/o Control	Total Expected Emission w/o Control	Control Measure and Efficiency	Total Expected Emissions w/ Control	Height of Emission Points	Number of Exhaust Points	Exhaust Point Diameter	Exhaust Gas Temperature	Exhaust Volume
Indirect Heat Retort Heater	240 million Btu/hr high-Btu gas (300,000 CFH)	Partic.	$5\ lb/10^6$ SCF (e)	18 lb/day	Treated and cleaned gas (k)	18 lb/day	100 ft	One	4.5 ft	300F	47,000 SCFM
		SO_2	$2\ lb/10^6$ SCF (h)	14 lb/day		14 lb/day					
		CO	$17\ lb/10^6$ SCF (e)	12 lb/day		12 lb/day					
		HC	$1\ lb/10^6$ SCF	0 lb/day		0 lb/day					
		NO_x	$700\ lb/10^6$ SCF	504 lb/day		504 lb/day					
Incinerator	300 million Btu/hr low-Btu gas (2,350,000 CFH)	Partic.	$0.042\ lb/10^6$ Btu (g)	151 lb/day	Treated and cleaned gas (k)	151 lb/day	100 ft	One	4.5 ft	800F	90,000 SCFM
		SO_2	$0.015\ lb/10^6$ Btu (h)	108 lb/day		108 lb/day					
		CO	$0.017\ lb/10^6$ Btu (e)	12 lb/day		12 lb/day					
		HC	$0.001\ lb/10^6$ Btu (e)	1 lb/day		1 lb/day					
		NO_x	$1.87\ lb/10^6$ Btu (g)	1,346 lb/day		1,346 lb/day					
Boiler	120 MM low-Btu gas 80 MM high-Btu gas (Emission factor for high-Btu gas as in IH retort heater above)	Partic.	$0.042\ lb/10^6$ Btu (g)	67 lb/day	Treated and cleaned gas (k)	67 lb/day	100 ft	One	3.25 ft	350F	50,000 SCFM
		SO_2	$0.015\ lb/10^6$ Btu (h)	48 lb/day		48 lb/day					
		CO	$0.017\ lb/10^6$ Btu (e)	9 lb/day		9 lb/day					
		HC	$0.001\ lb/10^6$ Btu (e)	Negligible		Negligible					
		NO_x	$1.87\ lb/10^6$ Btu (g)	545 lb/day		545 lb/day					
Oil Storage	170,000 barrels (5 tanks) 12,620 barrels/ day usage	HC	0.000018 lb/day (e) per 1,000 gal (Breathing loss)	Negligible	(Floating roof tanks) (e)	Negligible	50 ft	Five	1 ft	Ambient	–
Shale Disposal Traffic	1,350 mi/day 2,700 gal diesel fuel/day	Fugitive Dust	4.7 lb/mi (e)	6,345 lb/day	Wetting, speed control (90%) (e)	635 lb/day	Surface Surface	– –	– –	– –	– –
		Partic.	22 lb/1,000 gal (e)	59 lb/day	None (e)	59 lb/day		–	–	–	–
		CO	90 lb/1,000 gal	243 lb/day		243 lb/day					
		HC	28 lb/1,000 gal	76 lb/day		76 lb/day					
		NO_x	428 lb/1,000 gal	1,156 lb/day		1,156 lb/day					
		SO_2	31 lb/1,000 gal	84 lb/day		84 lb/day					
Processed Shale Disposal Storage	Up to 21,300 tons shale/day (3 months supply exposed)	Partic.	0.04 lb/ton load-in (d)	852 lb/day	Wet suppression (90%) (f)	85 lb/day	Surface	–	–	–	–
			0.018 lb/ton-yr wind erosion	96 lb/day	Wet suppression (90%)	10 lb/day	Surface	–	–	–	–

(a) Reference 4-1.
(b) Reference 4-2.
(c) Reference 4-3.
(d) Reference 4-4.
(e) Reference 4-5.
(f) Reference 4-6.
(g) Reference 4-7.
(h) Reference 4-8.
(i) Reference 4-9.
(j) Reference 4-10.
(k) Without control, SO_2 emissions will be reduced 99% by treating the gas prior to combustion. Without control, combustion particulate will be reduced by 50% by treating and cleaning the fuel. Without control, HC, CO, and NO_x emissions will be reduced by 90% through the use of treated gas, low NO_x burners, and combustion control. Emissions without control shown in the table include such allowances.

AIR POLLUTANT EMISSION INVENTORY
PHASE III

Activity	Material Handled	Pollutant	Emission Factor w/o Control	Total Expected Emissions w/o Control	Control Measure and Efficiency	Total Expected Emissions w/ Control	Height of Emission Points	Number of Exhaust Points	Exhaust Point Diameter	Exhaust Gas Temperature	Exhaust Volume
Mining	178,500 tons shale/day	Partic.	0.009 lb/hr-ton[a]	38,560 lb/day	Wet suppression and baffled settling chambers (98.5%)	578 lb/day	Surface	Four	28 ft	Ambient	11,250,000 SCFM
Blasting	96,500 lb ANFO/day	Partic.	0.01 lb/ton shale[b]	1,785 lb/day	Wet suppression and baffled settling chambers (98.5%)	27 lb/day	Surface	Four	28 ft	Ambient	11,250,000 SCFM
		CO	0.0211 lb/lb ANFO[b]	2,036 lb/day	None	2,036 lb/day					
		NO_x	0.0016 lb/lb ANFO[b]	155 lb/day	None	155 lb/day					
Primary Crushing	89,250 tons shale/day	Partic.	0.02 lb/ton[c]	1,785 lb/day	Same as above	27 lb/day	Surface	Four	28 ft	Ambient	11,250,000 SCFM
In-Mine Transfer (50)	178,500 tons shale/day	Partic.	0.004 lb/ton[i] transfer point	35,700 lb/day	Same as above	536 lb/day	Surface	Four	28 ft	Ambient	11,250,000 SCFM
In-Mine Mobile Equipment	30,000 gal diesel fuel/day (75,000 hp)	Partic	22 lb/1,000 gal[e]	660 lb/day	None	660 lb/day	Surface	Four	28 ft	Ambient	11,250,000 SCFM
		CO	90 lb/1,000 gal	2,700 lb/day		2,700 lb/day					
		HC	28 lb/1,000 gal	840 lb/day		840 lb/day					
		NO_x	428 lb/1,000 gal	12,840 lb/day		12,840 lb/day					
		SO_2	31 lb/1,000 gal	930 lb/day		930 lb/day					
Surface Transfer Points (110)	178,500 tons shale/day	Partic.	0.004 lb/ton[i] transfer point	78,540 lb/day	Venturi scrubber[e] (99.5%)	393 lb/day	50 ft	One hundred	1.46 ft	Ambient	5,000 SCFM each
Coarse Shale Storage Pile	5,000 tons/day (1,000,000 tons total on 10 acres)	Partic.	0.004 lb/ton[d] load-in	20 lb/day	Flexible chute (75%)	5 lb/day	Surface	One	10 acres	Ambient	—
			0.02 lb/ton-yr maintenance	55 lb/day	None	55 lb/day					
			0.018 lb/ton-yr wind erosion	49 lb/day	None	49 lb/day					
Secondary Crushing and Screening	178,500 tons shale/day	Partic.	0.6 lb/ton[j]	107,100 lb/day	Venturi scrubber[e] (99.5%)	536 lb/day	50 ft	Twelve	1.93 ft	Ambient	10,000 SCFM each
Fine Shale Storage	1,300 tons shale/day (1,300,000 tons average in pile)	Partic.	0.05 lb/ton[d] load-out	65 lb/day	Gravity reclaim (85%)[f]	10 lb/day	Surface	One	10 acres	Ambient	—
			0.02 lb/ton-yr maintenance	71 lb/day	None	71 lb/day					
			0.018 lb/ton-yr wind erosion	64 lb/day	None	64 lb/day					
Direct Heat Vertical-Type Retort (12)	148,800 tons shale/day	Partic.	0.004 lb/ton[i]	595 lb/day	Baghouse (99.5%)[e]	3 lb/day	50 ft	Twelve	1.93 ft	Ambient	10,000 SCFM each
Indirect Heat Vertical-Type Retort	11,600 tons shale/day	Partic.	0.004 lb/ton[i]	46 lb/day	Baghouse (99.5%)[e]	1 lb/day	50 ft	One	1.93 ft	Ambient	10,000 SCFM

Activity	Material Handled	Pollutant	Emission Factor w/o Control	Total Expected Emissions w/o Control	Control Measure and Efficiency	Total Expected Emissions w/Control	Height of Emission Points	Number of Emission Points	Exhaust Point Diameter	Exhaust Gas Temperature	Exhaust Volume
Fines-Type Retort (2)	19,400 tons shale/day	Partic.	0.004 lb/ton[i]	78 lb/day	Venture scrubber[e] (99.5%)	1 lb/day	50 ft	Two	1.93 ft	Ambient	10,000 SCFM each
Fines Retort Shale Preheater and ball Heater (2)	510,000 CFH high-Btu gas (500 million Btu/hr)	Partic. SO_2 CO HC NO_x	1.5% of feed[e] 2 lb/10^6 ft^3 [h] 17 lb/10^6 ft^3 [e] 1 lb/10^6 ft^3 [e] 700 lb/10^6 ft^3 [e]	580,000 lb/day 24 lb/day 21 lb/day 1 lb/day 857 lb/day	Treated and cleaned gas[k] (44.75% for Partic.)	1,450 lb/day 24 lb/day 21 lb/day 1 lb/day 857 lb/day	200 ft	Two	3.25 ft	130F	44,000 SCFM each
Indirect Heat Retort Heater	240 million Btu/hr high-Btu Gas (300,000 CFH)	Partic. SO_2 CO HC NO_x	5 lb/10^6 SCF[e] 2 lb/10^6 SCF[h] 17 lb/10^6 SCF[e] 1 lb/10^6 SCF 700 lb/10^6 SCF	18 lb/day 14 lb/day 12 lb/day 0 lb/day 504 lb/day	Treated and cleaned gas[k]	18 lb/day 14 lb/day 12 lb/day 0 lb/day 504 lb/day	100 ft	One	4.5 ft	300F	47,000 SCFM
Boiler Power Plant	4,550 million Btu/hr low-Btu gas 65 million Btu/hr high-Btu gas (Emission factor for high-Btu gas as in IH retort heater above)	Partic. SO_2 CO HC NO_x	0.042 lb/10^6 Btu[g] 0.015 lb/10^6 Btu[h] 0.017 lb/10^6 Btu[e] 0.001 lb/10^6 Btu[e] 1.87 lb/10^6 Btu[g]	2,300 lb/day 1,643 lb/day 189 lb/day 11 lb/day 20,557 lb/day	Treated and cleaned gas[k]	2,300 lb/day 1,643 lb/day 189 lb/day 11 lb/day 20,557 lb/day	250 ft	One	17 ft	350F	1,390,000 SCFM
Oil Storage	1,100,000 barrels (10 tanks)	HC	0.000018 lb/day[e] per 1,000 gal (breathing loss)	Negligible	(floating roof[e] tanks)	Negligible	50 ft	Ten	1 ft	Ambient	—
Processed Shale Moisturizer	138,300 tons shale/day	Partic.	0.004 lb/ton[i]	553 lb/day	Venturi scrubber[f] (99.5%)	3 lb/day	Surface 200 ft	Twelve Two	3 ft 4.5 ft	100F 100F	1,000 SCFM
Shale Disposal Traffic	6,000 mi/day 27,000 gal/day	Fugitive Dust Partic. CO HC NO_x SO_2	4.7 lb/mi[g] 22 lb/1,000 gal[e] 90 lb/1,000 gal 28 lb/1,000 gal 428 lb/1,000 gal 31 lb/1,000 gal	28,200 lb/day 594 lb/day 2,430 lb/day 756 lb/day 11,556 lb/day 837 lb/day	Wetting, speed[e] control (90%) None	2,820 lb/day 594 lb/day 2,430 lb/day 756 lb/day 11,556 lb/day 837 lb/day	Surface	—	—	—	—
Processed Shale Disposal Storage	148,000 tons shale/day (3 months supply exposed)	Partic.	0.04 lb/ton load-in[d] 0.018 lb/ton-yr wind erosion	5,920 lb/day 664 lb/day	Wet suppression[f] (90%) Wet suppression[f] (90%)	592 lb/day 66 lb/day	Surface Surface	— —	— —	— —	— —

(a) Reference 4-1.
(b) Reference 4-2.
(c) Reference 4-3.
(d) Reference 4-4.
(e) Reference 4-5.
(f) Reference 4-6.
(g) Reference 4-7.
(h) Reference 4-8.
(i) Reference 4-9.
(j) Reference 4-10.
(k) Without control, SO_2 emissions will be reduced 99% by treating the gas prior to combustion. Without control, combustion particulate will be reduced 50% by treating and cleaning the fuel. Without control, HC, CO, and NO_x emissions will be reduced by 90% through the use of treated gas, low NO_x burners, and combustion control. Emissions without control shown in the table include such allowances.

- All construction site roadways will be paved, oiled, graveled, or wetted, as required; construction traffic will be restricted, whenever possible, to these maintained roadways. Chemical stabilization may be used if considered necessary. Maintenance crews will keep construction area roadways as free as possible of wheel mud and load spills.

- All areas to be graded will be wetted by water sprays. Other areas where earth moving occurs will also be wetted during these operations. Wetting agents may be used if they prove effective in dust control or reducing water requirements.

Open Burning and Smoke Control. The open burning of combustible waste materials generated during either plant construction or operation will be allowed only when approval has been issued from the controlling agency. Burning will then be conducted in accordance with the terms of the approval. Debris for burning will be placed in piles with as little entrained dirt as possible, and in such a manner that burning is rapid and complete. Smoldering fires will be avoided. Residual ash will be transported to the processed shale disposal site for landfilling.

4.2.3.2 Operation Phases

As the WRSP development progresses from Phase I to Phase III, increasing amounts of air pollutants will be generated. The following paragraphs describe the air pollution control plans for various stages of the project.

Mining. The drilling, blasting, scaling, loading, transferring, and unloading operations essential to mining activities will generate a substantial amount of atmospheric pollutants. A large quantity of particulates (dusts) will be generated from all basic operations, and gaseous pollutants will also be generated from blasting and operation of diesel engines. Effective control measures will be required to minimize the amount of pollutants emitted to the atmosphere. The emission sources, uncontrolled emission rates, control measures, and final emission rates are summarized in Tables 4.2-4 and 4.2-5.

To minimize dust from mining activities, the following control measures will be implemented and maintained:

- During drilling, water will be applied at the drill bit. Wetting agents may be employed if they prove effective in reducing water requirements or in improving dust control.
- The muck pile of blasted shale may be wetted before and during rock loading. Wetting agents may be employed if they prove effective in reducing water requirements or in improving dust control
- Truck haulage roads will be maintained using conventional road wetting and chemical stabilization techniques
- Wet suppression techniques will also be used, if necessary, while scaling sides and roof of the working area

The gaseous air pollutants of primary concern are sulfur dioxide, carbon monoxide, nitrogen oxides, and hydrocarbons emitted from diesel engines and blasting. Proper maintenance of the engines is the most positive means of limiting these emissions. All diesel engines will be equipped to meet federal, state, and local air quality, health, and safety emission standards for underground operation.

The mine ventilation system will be designed to remove the blast fumes and dust from working panels. Before ventilation air is exhausted from the mines, it may be passed through mined-out panels that will act as settling chambers to reduce dust concentrations. Large openings and low ventilating current velocities will prevent the transportation of dust over long distances in the return air courses and will allow it to settle out. If this proves insufficient, additional water sprays may be installed near the bottom of the upcast shafts.

Blasting fumes will be controlled by using the proper explosives for the conditions encountered. The dust and fumes created will be diluted and removed from the working panels by an adequate amount of fresh air (up

to 12 million cubic feet per minute) through the mine ventilation system. Methane, if encountered, will also be diluted with these large volumes of ventilation air and exhausted.

Feed Preparation. Primary crushing will be conducted within the mine. The primary crushing units will be equipped with water sprays at the inlet hoppers to minimize fugitive dust. In addition, negative air pressure will be maintained on the inlet side of the crushers through a high-efficiency (99.5 percent or greater) wet scrubber. Cleaned exhaust air from the crusher and scrubber will be vented through the mine ventilation system described above. Dust emissions from the feed preparation, control measures, and the final emission rates are summarized in Tables 4.2-4 and 4.2-5.

The secondary crushing units and the screening units will be located above ground. Each crusher and screening unit will be equipped with a wet scrubber that will have negative pressure at the inlet. Air will be drawn through the crushing and screening units and processed through the wet scrubber (99.5 percent or greater efficiency). Cleaned air will be exhausted directly to the atmosphere.

Transportation and Stockpiling. Raw shale will be transported between the mine portal and the processing area by enclosed conveyor belts. To minimize fugitive dust from the movement of raw shale, all conveyor systems above ground will be fully enclosed, and wet scrubbers will be used at all conveyor exit points. The stacker at the raw shale stockpile will also be equipped with water sprays to minimize fugitive dust. The stockpiled raw shale will be in pieces up to 12-inches in size as received from the primary crusher, and there should be minimal wind erosion of the stockpile and little fugitive dust from the quiescent pile.

Retorting. In Phase I, two vertical-type retorts will process up to a total of 30,000 tons per day of raw shale. The raw shale will be transported to the retort by enclosed conveyor to minimize fugitive dust. The feed hoppers

will be equipped with a wet scrubber to control particulate emissions. Processed shale will be discharged to a water-filled quench tank or rotary cooler. Star valves with positive-pressure flue gases to provide an air lock will be used to remove processed shale from the retorts. Under normal conditions, no other emissions will result from the vertical-type retort.

In Phases II and III, the raw shale will be transported by a conveyor system from the secondary crushers to the vertical-type and fines-type retorts. A total of 95,700 and 178,500 TPSD, respectively, will be delivered to the retorts by this conveyor system. All raw shale conveyors will be enclosed to minimize fugitive dust. Vent gas from the processed-shale cooler containing steam, dust, and air will be scrubbed. In addition, the two indirect-heated retorts will use clean fuel (treated low-Btu gas) that will result in minimal stack emissions to the atmosphere.

The storage silo and surge bin of fine shale will be provided with a wet scrubber of 99.5 percent or greater efficiency. Exhaust gases from the ball elutriators and the shale preheater will be cleaned in the wet scrubbers of 99 percent or greater efficiency and released to the atmosphere through individual stacks (one for each fines-type unit). Vent gas from the processed-shale coolers will also be scrubbed.

Emissions from the retorting processes are described in detail in Section 4.2.2.

Shale Oil Upgrading. Shale oil will not be upgraded, except for the possible addition of a chemical agent to depress the pour point and make the oil suitable for pipelining. Sulfur removal units will recover sulfur from the retort off gas. Emissions to the atmosphere will be minimal; no additional controls will be necessary.

Boiler Plant. During Phase I, electrical power will be purchased. Process heat and steam will be produced in a small boiler, and excess retort off gas (treated) will be incinerated. Emission levels will be maintained at low levels by treating gas, using low NO_x burners, and controlling combustion.

Generation of steam for processing and for electrical power production during Phases II and III will involve the combustion of gas, possibly assisted by supplemental fuel. During Phase III operation, the utility boilers may consume up to 820 million cubic feet per hour of low-Btu gas. The gas will be treated, and its sulfur content will be less than 0.004 percent. Emissions to the atmosphere will be within pertinent federal new source performance standards, and represent best available control technology. Exhaust gases from the boilers will be emitted to the atmosphere through a single stack.

Processed Shale Disposal. The processed shale will be transported by semi-enclosed conveyors to a disposal site in Southam Canyon. These conveyors will be covered by a half-round culvert-like roof, and will also be provided with wind rails to prevent fine materials from being blown off. After being cooled, the shale will move from the retorting area by conveyor to a loadout bin. Trucks will transport the moist processed shale from the loadout bin to the disposal area. Since the shale will be moist, there will be little or no fugitive dust during transportation. At the disposal area, the shale may again be wetted by water spray as necessary to control dust. Grading of the disposed shale will be conducted with the shale in a moistened condition, and little dust should be generated during this process. Haul roads will be wetted to minimize fugitive dust from truck traffic.

4.2.4 NOISE POLLUTION CONTROL

Described below are guidelines for allowable noise, an inventory of expected noise sources during the White River Shale Project, planned controls, and a comparison of regulations and emissions.

4.2.4.1 Regulations, Standards, and Criteria

Although no local noise regulations exist, state and federal regulations and guidelines regarding both occupational (employee) and community noise will apply to the project.

Employee noise exposure limits are promulgated by the Federal Occupational Safety and Health Administration (OSHA), the Utah Occupational Safety and Health Administration (UOSHA), and the Mine Safety and Health Administration (MSHA). These regulations are explained briefly in Table 4.2-6. For community noise guidelines and criteria, the Environmental Protection Agency has established recommended noise levels in Information on Levels of Environmental Noise Requisite to Protect Public Health and Safety, March 1974.

A more detailed outline of both occupational and community regulations is included in Section 4 of the Summary of Environmental Regulations and Guidelines (Ref. 4-11).

Table 4.2-6

OCCUPATIONAL NOISE REGULATIONS

Agency	Law	Effect
Occupational Safety and Health Administration (OSHA)	Code of Federal Regulations, Title 29, Chapter XVII, Part 1910, Subpart G, 36 FR 10466, May 29, 1971	Establishes noise exposure limits for workers; these limits are a function of intensity and duration of exposure
Mine Safety and Health Administration (MSHA)	Public Law 191-173, Subpart B, Section 70.300-5	As above
Utah Occupational Safety and Health Administration (UOSHA)	Utah Safety Rules and Regulations, Part 1910.95	Identical to OSHA regulations, with the exception of an addendum that allows UOSHA to request audiometric testing if there is evidence of hearing damage

4.2.4.2 Noise Sources

The project will have three major types of noise sources: construction, operation, and traffic.

Construction Noise Sources. Major noise sources and corresponding untreated equipment noise levels during construction are shown in Table 4.2-7.

Table 4.2-7

CONSTRUCTION NOISE LEVELS
FROM TYPICAL UNTREATED EQUIPMENT

Equipment	At Operator Position	At 50 Feet
Earth-Moving Equipment	80-105 dBA	75-95 dBA
Drilling	95-112 dBA	80-97 dBA
Blasting	90-115 dB[a]	135 dB

(a) Peak sound pressure levels.

Operation Noise Sources. While operating the facility, noise will be generated by mining and processing. Since the noise sources associated with each differ considerably, they are listed separately in Tables 4.2-8 and 4.2-9.

Traffic Noise Sources. Traffic noise will come from employee passenger cars and supply trucks. The volume of traffic will vary throughout the construction periods as will the traffic noise. The L_{eq} noise levels caused by project-related traffic are estimated to range from 32 to 57 dBA at the nearest residence in Bonanza.

4.2.4.3 Control Equipment and Procedures

A variety of generalized techniques exist for controlling equipment noise; these will be used independently or in combination to achieve the desired control. These techniques are generally applicable in controlling both occupational and community noise. They can be used to control noise at

Table 4.2-8

MINING NOISE LEVELS FROM TYPICAL UNTREATED EQUIPMENT

Equipment	At Operator Position (dBA)
Drills	80-104
Scalers	85-103
Roof Bolters	85-106
Loaders	85-108
Blasting	(90-140 dB peak)
Trucks	85-98
Crushers	105-115
Vibrating Screens	95-110
Ventilation Fans	70-95[a]

(a) No operators, noise level at 50 feet.

Table 4.2-9

PROCESSING NOISE LEVELS FROM TYPICAL UNTREATED EQUIPMENT

Equipment	At 3 Feet (dBA)
Atmospheric Relief and Vent Valves	100-140
Control Valves and Piping Systems	80-100
Cooling Towers and Forced-Draft Coolers	85-95
Blowers and Fans	85-110
Compressors	95-110
Pumps	80-105
Motors	80-105
Gears	80-100
Solids Conveyance Equipment	75-115
Rock Crushers	100-110
Vibrating Screens	100-110
Trucks	90-110
Steam Turbine	85-95
Flares	110-130

its source, prevent its transmission, or isolate the receiver from the noise and include the following:

- Natural community noise attenuation from terrain barriers and foliage
- Accoustical absorbing materials inside buildings, cabs, and enclosures
- Lagging (acoustical wrapping or cover)
- Equipment enclosure that may be close-fitting, walk-in, or room
- Barrier wall
- Noise-limited equipment
- Silencers and mufflers
- Vibration isolation
- Vibration damping
- Personnel enclosures and cabs
- Personnel walkways
- Restriction of personnel access
- Reduction in personal vehicles on tract

In particular areas where engineering noise control is not cost-effective, the following administrative noise controls may be used:

- Reduced exposure time for personnel
- Relocation of personnel
- Wearing of protectors for certain personnel

Noise generated by equipment can affect both occupational and community noise levels. Since community impacts from the noise of project construction and operation are expected to be insignificant, these techniques are expected to be directed largely toward limiting occupational noise exposures.

Worker noise exposure will be monitored periodically as a part of the industrial health and safety programs of both construction and operation. The project safety officer is responsible for worker health and safety, which includes compliance with OSHA and MSHA noise regulations.

Construction Noise Control. Employee noise exposures during construction will be limited by a variety of methods including using noise-limited construction equipment, administratively controlling working patterns and locations, and wearing protectors when other controls are inadequate or infeasible.

The peak sound pressure level, or peak overpressure of blasting noise, will be controlled by regulating the amount of explosives and by burying the explosive.

Operation Noise Control. Since the equipment used in the operation of the facility can be considered permanent or semipermanent in use of design, more specific noise control procedures can be outlined for the operation phase than for the construction phase.

Mining. Mining noise control is discussed in Section 3.5.7.

Processing. Processing will involve a great variety of equipment noise sources. Both the type and extent of noise control required will depend on location, operating parameters, employee work patterns, and available technology.

An equipment noise specification program will be used to reduce noise from some original equipment and will establish limits on noise emissions of large equipment. The equipment layout of the facility will be reviewed to establish equipment locations that optimize employee noise isolation where feasible.

Other engineering controls of major noise sources that may be considered during the design stage of the facility include the following:

- Atmospheric Relief and Vent Valves. Locating safety valve and relief valve systems at a great enough distance from exposed personnel will permit normal distance and air attenuation noise reduction from the noise source to any potential exposed personnel. Quiet valves and vent silencers will be used when necessary.

- Control Valves and Piping Systems. Noise will be reduced by using in-line silencers and specifying and installing low-noise valves. Pipe lagging will also be used as required.

- Air-Cooled Heat Exchangers and Cooling Towers. Air cooler noise can be reduced by reducing fan tip speed, improving blade design, and increasing the number of fan blades. Air cooler fan tip speed should be low enough to satisfy in-plant noise level requirements. The plant will be laid out with cooling towers away from normally occupied areas.

- Blowers and Fans. Silencers on fan inlets and outlets, enclosures, and lagging will be used as needed.

- Compressors. The maximum permissible noise level for purchased compressors will be specified. Measures that may be used to reduce noise include: inlet and discharge pipe silencers, low-noise types of valves, antisurge bypass systems, and noise-attenuating casings or enclosures. Motor drives will be of the low-noise type. Gear reducers may require acoustical enclosures.

- Large Pumps or Multistage Rotary or Cavitating Pumps. It may be necessary to lag or acoustically enclose such equipment to reduce noise.

- Motor Noise. There are wide differences in noise generation between motors of different types; size alone is not a reliable guide. As a general rule, large standard high-speed motors (3,600 rpm) are excessively noisy. Unless the noise is properly attenuated, the combined effect of the large number of motors located in plant areas can produce a significant noise level. Quiet low-speed motors will be used where possible, and provisions for fan silencers and acoustic enclosures will be made as required.

- Gears. Gear train noise will be reduced by the use of vibration isolation and enclosures where required.

- Solids Handling Equipment — Belt and Pneumatic Conveyors. Impacts of solids on solids and on equipment metal will cause vibrations and noise. Such noise will be reduced by minimizing solid free-fall, adding vibration dampening material to metal panels, and using acoustical lagging and acoustical enclosures as required.

- Rock Crushers. The operator will be provided with an acoustical enclosure that will allow him to monitor and control the rock crushers in a low noise level environment.

- Vibrating Screen Housings. Vibrating screen housings will be treated with vibration damping material to reduce radiated noise. Sound absorbing and lagging materials and vibration isolation systems will be used as required.

- Haulage Trucks. Noise will be controlled by using mufflers and sound-attenuated cabs. Noise control planning for the entire plant will consider truck loading station locations, truck traffic routes, and truck scheduling.

- Steam Turbine-Generators. Turbines will have acoustic enclosures.

- Flares. Flare noise will be reduced by employing flame subdivision at the burners. Seal drums will be equipped with antislosh baffles to prevent combustion pulsations. Elevating flares will reduce exposure to workers on the ground.

Because of design limitations, these engineering controls will sometimes not sufficiently limit employee noise exposures and, in such cases, administrative controls will be used. Such controls include the manipulation of employee schedules and work locations. Normally traveled and manned areas where excessive noise levels exist will also be posted.

During special or infrequent maintenance operations requiring access to noisy areas, hearing protectors will be used to limit noise exposure.

Areas of excessive noise unforeseen during the design stage of the facility will be pinpointed through noise surveys and additional or alternative noise control procedures can be adopted if indicated.

4.2.4.4 Comparison Between Regulations and Controlled Emission Rates

Occupational. All employee noise exposures will be controlled to minimize occupational hazards to hearing and to comply with both OSHA and MESA regulations outlined in the Summary of Environmental Regulations and Guidelines (Ref. 4-11).

Community. Community noise levels without specific control procedures will be well within "acceptable" ranges outlined by both HUD and EPA criteria (Ref. 4-11) and marginally above ambient levels during some periods (see Section 5.2.6).

Traffic Noise. Community noise resulting from traffic may be lessened by reducing the volume to employee vehicle traffic to and from the facility. This will be accomplished by encouraging bus transportation or car pools; however, even without such measures, the resulting community noise still falls in the "normally acceptable" range of HUD criteria.

4.3 SOLID WASTE DISPOSAL PLAN

4.3.1 REGULATIONS, STANDARDS, AND GUIDELINES

The Oil Shale Lease Requirements and the federal and state regulations governing the disposal of non-hazardous and hazardous solid waste are summarized in Section 7 of the Summary of Environmental Regulations and Guidelines (Ref. 4-11). The regulations and guidelines generally pertaining to solid waste disposal include:

- Federal Oil Shale Lease: Environmental Stipulations, Sections 9C, 14B, 14C, 14D, and 14E
- United States Environmental Protection Agency: 40 CFR Parts 241, 256, 257, 260, 261, 262, 263, and 264
- Utah State Department of Social Services, Division of Health: Title 26, Chapter 15, Part 5, UCA, 1953, as amended July 17, 1974

Pertinent requirements for the design and operation of the disposal site are as follows:

- All plans, disposal sites, and procedures will be approved by the Area Oil Shale Supervisor, the Utah State Division of Health, and the U.S. Environmental Protection Agency.
- Disposal of non-hazardous wastes will be through landfill.
- Disposal of hazardous wastes will be in accordance with RCRA requirements.
- Sites will be planned and operated to minimize erosion and landslides.
- Fill methods will be used that reflect the best practicable system.
- Finished surfaces will be revegetated.
- Saline and toxic drainage will be prevented from contacting natural ground and surface water resources.

4.3.2 WASTE SOURCES

Various types and quantities of solid waste, other than overburden and processed shale, will be processed during the construction and operation phases of the project. Tables 4.3-1 and 4.3-2 list the solid waste sources and quantities expected during the major phases of the project. The quantities of solid waste shown in the tables are approximate and will be revised when engineering information becomes available.

4.3.2.1 Phase I

Construction. Typical kinds of waste construction materials expected during the 3-year construction period are shown in Table 4.3-1. Miscellaneous waste such as general trash and garbage will be generated by construction workers and field personnel. The small amount of used lubricants may be economically salvageable.

Mine and Plant Operation. Mining of raw shale is expected to reach a production level as high as 30,000 tons per day (TPD) in Phase I. The dust collected from the primary crusher will be the major waste and will be left in the mine. Shop and warehousing activities in the mine will result in small amounts of miscellaneous wastes along with employee-related trash and garbage. Waste quantity estimates listed in Table 4.3-1 are based on a shale production rate of 26,700 TPSD.

The Phase I facility will produce operations-related waste. Dust will be collected from secondary crushing and screening units and from the retort. These dusts will be similar in composition to their respective parent materials. The sulfur removal unit will produce low-grade elemental sulfur in cake form. Because of its quality, this sulfur will be stored in a separate stockpile (see Figure 3.4-2) for possible later recovery and use. The sulfur storage area will be designed to prevent contamination of ground and surface water supplies. Although Stretford sulfur removal units were used as the basis for this document, other sulfur removal systems may also be considered and used in the project as a result of more detailed engineering evaluations.

Table 4.3-1

SUMMARY OF MAJOR SOLID WASTES, PHASE I

Waste Source	Type and Major Constituents	Approximate Disposal Quantity	Waste Collection and Storage	Waste Disposition
		Phase I Construction		
Various Construction Activities	Construction debris – lumber, packing, concrete, scrap metal, etc.	3 TPD (avg)	Collected in twenty 45-cubic-yard bins; load directly on trucks	Picked up and hauled by truck to landfill site for deposition
Equipment Maintenance	Waste oils	Small amounts	Collected in drums for salvage	Hauled away periodically for reclaiming or disposal
Employee Facilities	General trash and garbage	0.4 TPD (avg)	Collected in one 3-cubic-yard bin	Picked up and hauled by truck to landfill site for deposition
		Phase I Mining		
Primary Crushing	Raw shale dust	2.2 TPD (dry)	Settling	In-mine settling in mined-out panels
Shop Warehouse Employee Facilities	General trash and garbage	0.2 TPD	Collected in one 3-cubic-yard bin	Taken to surface and hauled by truck to landfill site for deposition
		Phase I Operation		
Secondary Crushing, Screening, and Surface Transfer	Raw shale dust	41 TPD (dry)	Wet suppression and scrubber	Slurry pumped to processed shale moisturizer; conveyed to processed shale disposal site
Retort Raw Shale Feeding	Raw shale dust	0.41 TPD (dry)	Wet scrubber and settling tank	Slurry pumped to processed shale moisturizer; conveyed to processed shale disposal site
Retort Processed Shale Discharge	Processed shale dust	5.3 TPD (dry)	Wet scrubber and settling tank	Slurry pumped to processed shale moisturizer; conveyed to processed shale disposal site
Water Treatment Facility	Water treatment filter solids	Small amounts	Settling tank	Slurry pumped to processed shale moisturizer; conveyed to processed shale disposal site
Stretford Unit	Elemental sulfur slurry	10.3 TPD (dry)	Centrifuged sulfur reslurried with water in a holding tank	Placed in separate storage pile for later recovery
Shops, Warehouse, and Employee Facilities	General trash and garbage	0.2 TPD	Collected in one 5-cubic-yard bin	Picked up and hauled by truck to landfill; spread and covered
Sanitary Wastewater Treatment	Digested biological sludge	Small amounts	Stored in drying beds for future use	Used for soil conditioning during revegetation
Equipment Maintenance/ Lab/Gravity Separator	Waste oils, chemicals, skimmed oils	Small amounts	Collected in drums for salvage	Fed to retort or hauled off tract for reclamation

Table 4.3-2

SUMMARY OF MAJOR SOLID WASTES, PHASES II AND III

Waste Source	Type and Major Constituents	Approximate Disposal Quantity	Waste Collection and Storage	Waste Disposition
		Phase II and III Mine and Plant Construction		
Various Construction Activities	Construction debris lumber, packing, concrete, scrap metal, etc.	15 TPD (avg)	Collected in twenty 45-cubic-yard bins; loaded directly on trucks	Picked up and hauled by truck to landfill, spread, and covered
Shops, Warehouse, and Employee Facilities	General trash and garbage	2 TPD	Collected in one 5-cubic-yard bin	Picked up and hauled by truck to landfill, spread, and covered
Equipment Maintenance	Waste oils	About 1 TPW	Collected in drums for salvage	Hauled away periodically for reclaiming or disposal
		Phase II Mining[a]		
		Phase II Operation[b]		
		Phase III Mining		
Primary Crushing	Raw shale dust	40 TPD (dry)	Settling	Allowed to remain in mined-out panels
Equipment Maintenance	Waste oils	About 1 TPW	Collected in drums for salvage	Hauled to slop oil tanks for reclaiming
Shops, Warehouse, and Employees Facilities	General trash and garbage	2 TPD	Collected in one 5-cubic-yard bin	Taken to surface and hauled by truck to landfill site for disposition
		Phase III Operation		
Secondary Crushing, Screening, and Surface Transfer	Raw shale dust	863 TPD (dry)	Wet suppression and scrubber	Pumped to processed shale moisturizer; conveyed to processed shale disposal site
Raw Shale Feeding to Vertical Retorts	Raw shale dust	6.8 TPD (dry)	Wet scrubber and settling tank	Pumped to processed shale moisturizer; conveyed to processed shale disposal site
Processed Shale Discharge from Vertical Retorts	Processed shale dust	126 TPD (dry)	Wet scrubber and settling tank	Pumped to processed shale moisturizer; conveyed to processed shale disposal site

Table 4.3-2 (Continued)

Waste Source	Type and Major Constituents	Approximate Disposal Quantity	Waste Collection and Storage	Waste Disposition
Raw Shale Feeding to Fines-Type Retorts	Raw shale dust	2.4 TPD (dry)	Wet scrubber and settling tank	Pumped to processed shale moisturizer; conveyed to processed shale disposal site
Fines-Type Retorts	Attrited alumina balls	700 TPY (average)	Discharged from retorts along with processed shale	Conveyed along with processed shale to processed disposal site
Fines-Type Retort Preheater Exhausts	Raw shale dust	360 TPD (dry)	Wet scrubber and settling tank	Pumped to processed shale moisturizer; conveyed to processed shale disposal site
Fines-Type Retort Ball Elutriators	Processed shale dust	30 TPD (dry)	Wet scrubber and settling tank	Pumped to processed shale moisturizer; conveyed to processed shale disposal site
Fines-Type Retort Process Shale Moisturizer Exhaust	Processed shale dust	1.9 TPD (dry)	Wet scrubber and settling tank	Pumped to processed shale moisturizer; conveyed to processed shale disposal site
Stretford Unit	Elemental sulfur slurry	85 TPD (dry)	Centrifuged sulfur	Placed in a separate stockpile for later recovery
River Water Treatment	Water treatment sludge	3 TPD (dry)	Settling tank	Pumped to processed shale moisturizer; conveyed to processed shale disposal site
Sanitary and Process Wastewater Treatment	Digested biological sludge	0.5 TPD (dry)	Stored in drying beds for future use	Used for soil conditioning
Process Wastewater Treatment	Skimmed oils	15 TPD	Pumped to slop oil tanks	Reclaimed
Equipment Maintenance, Laboratory	Waste oils and chemicals	1 TPW	Collected in drums for salvage	Disposition dependent on chemical or oil
Shops, Warehouse, Employee Facilities	General trash and garbage	5 TPD	Collected in one 5-cubic yard bin	Picked up and hauled to processed shale landfill area, spread, and covered

(a) During Phase II mining, about one-half as much waste will be produced as during Phase III. The waste sources, types, and disposition will be the same as Phase I.
(b) During Phase II operation, about one-half as much waste will be produced as during Phase III. The waste sources, types, and disposition will be the same as Phase I.

Small amounts of waste sludges will be produced from water treatment, wastewater treatment, and wastewater oil skimming. Other miscellaneous waste, such as plant trash and garbage, will result from plant employees activities during the Phase I facility operation. All of these wastes except sulfur will be disposed of in an appropriate landfill.

4.3.2.2 Phases II and III

Table 4.3-2 summarizes the solid wastes expected to be generated during Phases II and III. During the 7-year construction period of Phases II and III, field activities will be similar to those of Phase I, but on a larger scale. Hence, sources and types of solid waste will also be similar. The solid waste quantities reflect the larger field construction force and the larger quantities of construction materials.

The solid waste sources and types for Phases II and III mining and plant operation will be the same as those for Phase I. As shown on the table, about half as much waste will be produced at the Phase II mining rate than at the Phase III mining rate.

Shale dust collected in various air pollution control facilities will constitute about 80 percent of the total solid waste excluding the processed shale. Dust collection facilities will include scrubbers for secondary and tertiary crushers, retort feed and discharge points, processed shale moisturizers, ball elutriators, and raw shale preheaters. Other routine waste will include elemental sulfur from the Stretford unit (stockpiled separately), sludge from water treatment, skimmed oil, and biological sludge from wastewater treatment, and general plant trash and garbage.

4.3.3 WASTE HANDLING, STORAGE, AND DISPOSAL SYSTEMS

The handling, storage, and disposal of solid waste will be carried out in a manner that will protect health and safety and the environment. Solid waste will be put in containers suitable for temporary storage. Waste will

be picked up on a regular schedule and transported to the disposal site in the processed shale disposal area.

Any hazardous wastes generated will be disposed of at an approved site, according to state and federal hazardous waste permit requirements. However, at this time it is expected that all potentially hazardous wastes will not be disposed of but will be recycled to the greatest degree possible.

4.3.3.1 Phase I

Waste from Construction. Various sizes of bulk containers (10, 20, and 40 cubic yards) will accumulate and store construction waste until picked up. General trash and garbage will be put in small, leakproof container bins equipped with tight-fitting covers to prevent littering or attracting of disease vectors. Other materials, such as waste chemicals, oils, or oily materials, will be put in leakproof, fireproof containers for temporary storage. The placement of containers, their number and type, and the frequency of pickup will vary during the construction phases.

Construction waste will be trucked to the processed shale disposal area and landfilled. An all-weather access road to the landfill site (in a side canyon on the eastern ridge of Southam Canyon) will be developed as part of site preparation for processed shale disposal. Water spraying equipment will control dust on the access road and at the site.

Landfilling by the area method will probably be employed. Solid waste discharged at the working face will be spread, compacted in shallow layers, and covered. Excess construction overburden may be used for cover material; if this material is not available, local material will be used. Cover material will be sufficiently deep to minimize rain water percolation and to prevent animals from burrowing into the waste layers. A catchment constructed west of the initial processed shale disposal area will collect any runoff or leachate from the disposal area. This landfill will be buried by processed shale during Phase I operation.

Waste from Operation. Process-related waste will be handled somewhat differently than construction waste. Non-hazardous waste collected in a slurry form will be used along with water to moisturize processed shale and will go to the disposal area on the processed shale conveyor and processed shale hauling vehicles. Slurry waste includes raw and processed shale dust collected in wet scrubbers, and water treatment filter sludges. Stretford unit sulfur will be stockpiled separately as a solid for later recovery. Waste will be transported in closed systems from source to the truck loading bin located in the processed shale disposal area.

Other solid waste, such as trash and garbage from the mine and the plant area, will be handled in a more conventional manner. It will be accumulated in containers and picked up regularly by collection vehicles and transported to the deposit site. Digested biological sludge will be stored in drying beds for possible later use as a soil conditioner. Waste oils and chemicals will be collected in drums; the collected material will be hauled off site for reclamation if feasible, or buried in accordance with applicable RCRA rules.

Solid waste disposal will be part of the processed shale disposal and its associated environmental control activities. Waste trucked to the disposal sites will be spread, compacted, and covered with processed shale. The processed shale cover will be several feet thick and will be compacted to minimize percolation and leachate generation.

Procedures for control of dust, erosion, surface runoff, and leachate from the processed shale disposal area will meet environmental protection standards.

4.3.3.2 Phases II and III

Waste from Construction. Construction waste from mine development and plant construction for Phases II and III will be handled in the same manner as in Phase I. The quantities of waste will be larger and the sources more

widespread. Container distribution and waste pickup frequency will be commensurate with the sources, types, and quantities of waste being generated throughout this construction phase.

Construction waste will be landfilled in Southam Canyon and buried by processed shale. The landfill operations and associated environmental control procedures will be basically the same as those used in Phase I. The landfill area will be located away from major drainage channels in Southam Canyon to minimize potential interference with surface water movement.

Waste from Operation. During Phase II operation, process-related waste as well as waste from Phase III construction will be handled. Waste collection procedures used during Phase I will be applicable throughout Phases II and III. In the latter phases, provisions will be made for handling increased quantities.

Solid waste collected in the plant and mine (except slurry waste) will be trucked to the processed shale disposal area. As in Phase I, dust collected in various air pollution control facilities — all in slurry form — will be added to the processed shale and transported by covered or closed conveyors to the processed shale disposal area. Solid waste will be landfilled using the same procedures used in Phase I.

4.3.4 SUMMARY OF DISPOSAL PLAN

The solid waste disposal plan is intended to comply fully with the applicable environmental stipulations in the Federal Oil Shale Lease and with the Utah State Code of Solid Waste Regulations and with federal RCRA requirements. In summary:

- Solid waste will be put in approved containers for temporary storage.
- Solid waste will be picked up regularly and transported in appropriate collection vehicles to the disposal site.

- Slurry waste will not be landfilled directly but will be used to moisturize processed shale.

- Special handling and disposal procedures will be used for potentially hazardous materials.

- Solid waste will be disposed of in the processed shale disposal area using accepted landfill techniques (spread, compact, cover).

- Disposal sites in the processed shale disposal area will be located to minimize effects from natural drainage channels and groundwater.

- Adequate equipment and manpower will be maintained at the disposal site to conduct the landfill operation and to provide effective dust and litter control.

- Any surface runoff or leachate from the disposal area will be impounded.

- The processed shale pile, containing the solid waste, will be contoured and revegetated.

4.4 WATER POLLUTION CONTROL

4.4.1 PROTECTION OF EXISTING WATER RESOURCES

4.4.1.1 During Construction

As discussed previously, all on-tract construction activities will be planned to avoid lowering the quality of surface and subsurface water sources. Catchment basins and runoff diversions, protective measures for controlling seepage and percolation, and maximum reuse of wastewater will result in no discharge of contaminated runoff to natural surface and subsurface water bodies.

4.4.1.2 During Operation

All operation activities of the White River Shale Project will be planned to result in zero wastewater discharge. All waste streams and contaminated runoff from the process area will be diverted to catchment basins. The streams will then be treated and reused in the process activities or for dust suppression (see Section 3.15). Runoff from Southam Canyon, including the processed shale disposal area, retained by the Southam Canyon retention dam and the processed shale will be used for dust control and processed shale compaction at the disposal site. Slope dressing and planting procedures in the processed shale revegetation program are designed to catch and retain all precipitation (up to the 100-year storm) that falls directly onto the finished pile surface. This water will be available for use by vegetation.

Aspects of water drainage and erosion control for the project are discussed in greater detail in Section 4.5.

Water supply systems will result in water withdrawal from the White River (estimated average pumping rates) of about 1,500 gpm during Phase I, 8,000 gpm during Phase II, and 16,000 gpm during Phase III, assuming that the dam is constructed as presently scheduled. Alternate water supply sources are discussed in Section 7.

4.4.2 REGULATIONS, STANDARDS, AND GUIDELINES

A sound wastewater management plan will be adopted by the White River Shale Project to prevent water pollution caused by the project. The goals of this management plan are:

- Zero discharge of wastewater
- Optimum use and reuse of water and wastewater
- Judicious selection of treatment facilities
- Compliance with all applicable regulations

The plan is described in detail in Section 3.15. Alternative plans and the rationale for selection of the proposed plan are discussed in Section 7.15. This subsection summarizes the legal requirements, wastewater sources, and control procedures.

4.4.2.1 Legal Requirements

Construction and operation of the wastewater treatment facilities are mainly governed by the following regulations and conditions:

- Bureau of Land Management, Sale of Oil Shale Leases (U-25918, U-26194, and amendments). The lease, with its environmental stipulations, is the main document regulating the White River Shale Project activities. The lessee is required to:
  - Comply with all applicable federal, state, and local water pollution control and water quality regulations
  - Conserve the mineral and other resources (including water)
  - Avoid, minimize, and repair damage to the land, water, and air
  - Take all measures to protect the health and safety of all persons affected by activities of the lessee
- Resource Conservation and Recovery Act (RCRA). This contains facility standards for the treatment, storage, and disposal of hazardous wastes.

- Utah Waste Disposal Regulations (as authorized by the Utah Water Pollution Control Act — Utah Code Annotated, 1953, 26-15-485 and 73-1 through 13, as amended). These regulations presently involve the following:

  - Part I (revised 1978): Definitions and General Requirements

  - Part II (revised 1978): Standards of Quality for Waters of the State

  - Part III (revised 1965): Sewers and Wastewater Treatment Works

  - Part IV (revised 1967): Individual Wastewater Systems

  - Part V (revised 1967): Small Underground Wastewater Disposal Systems

Regulations pertaining to wastewater discharge specifications and permits are not strictly applicable to the WRSP, since the proposed wastewater management plan calls for zero discharge. However, these regulations include:

- Clean Water Act (33 U.S.C. 1251-1376; 40 CFR 6, 122, 125, 133)

- Utah Water Pollution Control Act (Utah Code Annotated, 1953, Title 73, Chapter 14, as amended)

- Utah Waste Disposal Regulations (Utah Code Annotated, 1953, 26-15-4 and 5, and 73-1 through 13, as amended)

In addition, the Colorado River and its tributaries are protected by the requirements of "Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control." These were written by the Colorado River Basin Salinity Control Forum in 1978, and were approved and adopted by each of the seven Colorado River Basin states (which includes Utah). These are implemented through the NPDES Permit Program.

A detailed summary of all pertinent environmental regulations is presented in Section 6 of the Summary of Environmental Regulations and Guidelines (Ref. 4-11).

4.4.2.2 Wastewater Sources

The wastewater streams will include domestic wastewater from employee facilities and a variety of streams from the mining, retorting, and processing facilities (see Table 4.4-1). Sources and characteristics are discussed in Sections 3.15 and 3.19.

Table 4.4-1

WASTEWATER SOURCES
(gpm)

Wastewater Streams	Phase I		Phases II and III		
	Construction	Operation	Construction	Phase II Operation	Phase III Operation
Domestic Wastewater	(a)	10	50	25	45
Sour Water	-	25	-	630	1,250
High TDS	-	10	-	380	755
Oily Washdown	-	20	-	150	290
Storm Runoff[b]	40	40	45	45	45
Saline Mine Water	Nil	Nil	Nil	Nil	Nil

(a) Contractor chemical toilets will be used.
(b) Acre-feet of expected surface runoff during the 100-year storm.

4.4.2.3 Control Procedure

The proposed wastewater management plan includes procedures for wastewater collection, treatment, and reuse. Wastewater streams will be segregated, collected, and treated according to the type of contaminant. The use of optimum treatment systems is planned to achieve zero discharge through total wastewater reuse. The treated wastewater is reused as makeup to the scrubbers for the secondary crushers. Later, the wastewater is reused again to cool the processed shale. Any excess reclaimed water would be used in revegetation of the shale disposal pile. Figure 4.4-1 shows an overview of the proposed control plan.

4.4.3 REMOVAL OF OIL AND OTHER HAZARDOUS MATERIALS

This subsection discusses plans to prevent spills of oil and hazardous materials. Implementation of the plans minimizes the threat of pollution to waterways.

4.4.3.1 General

Spill prevention will be achieved by the following activities:

- Designing facilities and equipment to preclude spills, insofar as practicable
- Training personnel in proper and safe operation procedures, good housekeeping and maintenance practices, and awareness of spill potential
- Scheduling regular inspection and maintenance of facilities and equipment

Preventive and emergency cleanup measures are amplified in Section 4.11.

4.4.3.2 Facility Drainage

Oil traps or skimmers will be inspected regularly for oil accumulations. The accumulated oil will be returned to storage or disposed of by approved methods. Runoff from contaminated areas will be collected and treated

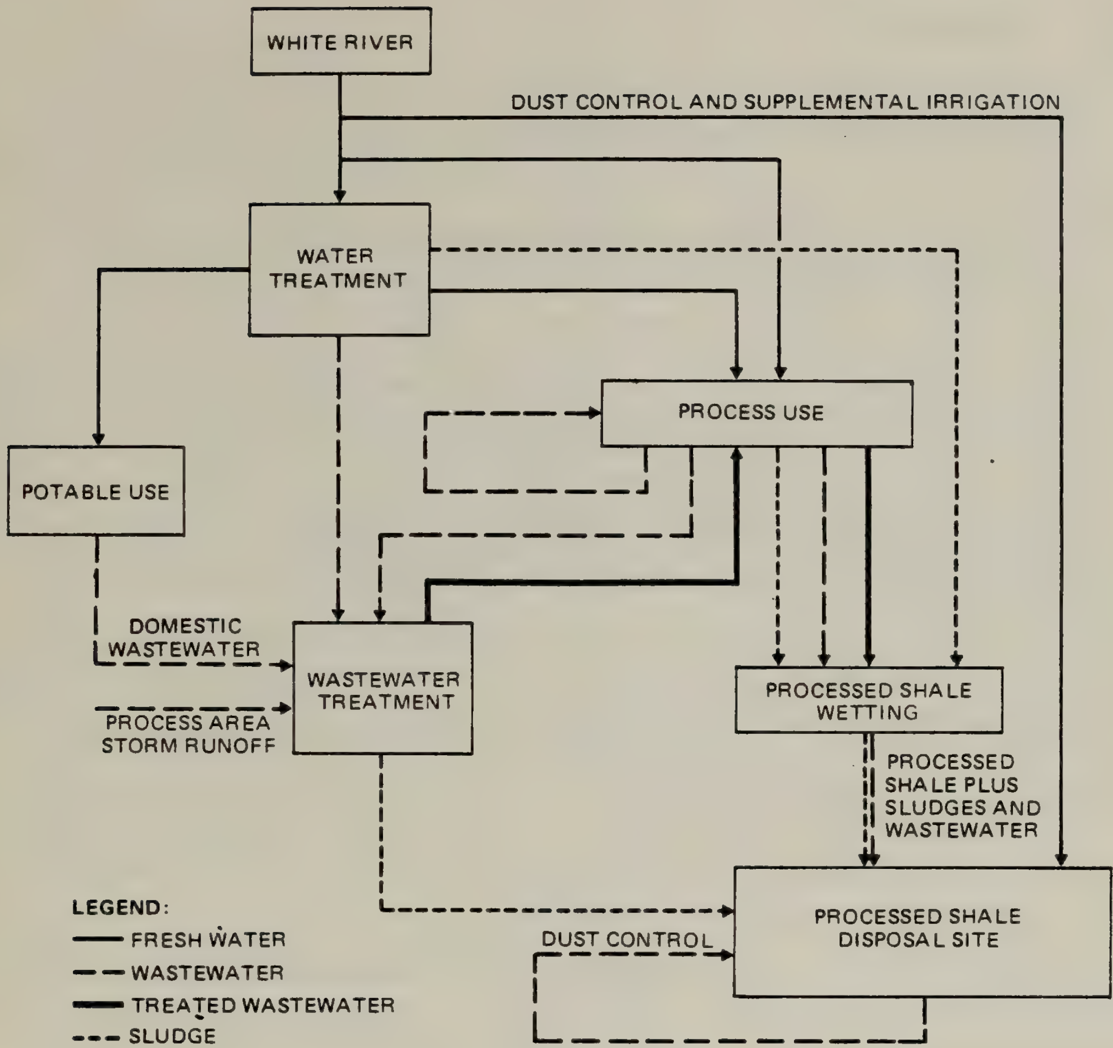

Figure 4.4-1 OVERVIEW OF WASTEWATER MANAGEMENT PLAN (Actual flows are provided on Figures 3.15-2 and 3.15-3.)

(see Section 3.15). Details of the plant drainage scheme are presented in Section 3.13.

4.4.3.3 Storage Tanks

Oil storage tanks will be designed, built, and tested in accordance with all applicable regulations and will be compatible with the materials stored. Spill prevention features incorporated into tank design will include adequate sizing, use of overflow lines, adequate vacuum or overpressure protection, and a liquid-level sensor.

Oil, petroleum products, industrial chemicals, and similar toxic or volatile materials in substantial quantities (more than 500 gallons) will be stored in an area surrounded by impermeable containment dikes. The volume of the containment dikes will be at least: 1) 110 percent of the largest tank plus displacement of all other tanks in the compound below the dike height or liquid level, plus 2) a volume sufficient for maximum trapped precipitation and run-off that might be impounded at the time of a spill. The earthen dike will have a flat surface 3 feet wide on top of the dike.

Diked storage areas will have manual valves that will be normally closed. The retained stormwater will be examined for the presence of oil before each draining to the wastewater treatment plant. If there is enough oil on the water surface to permit skimming with vacuum pumps, such oil will be recovered before the water is drained. All tanks will be visually examined regularly to detect conditions that may require maintenance.

4.4.3.4 Transfer and Fueling Operations

The White River Shale Project will maintain an equipment fueling station and tanker truck loading-unloading facilities where the following spill prevention measures will be observed:

- All piping, pumps, and meters will be protected from equipment and rolling stock by posted signs and physical barriers.

- Tanks will not be filled beyond rated capacities.
- Tank vents will be kept free of blockage.
- All fuel tanks will be clearly marked as to type and grade of product.
- Equipment records for each tank will reflect all operating data and repairs.
- All valves will be checked before starting any pumping operation to ensure that they are properly positioned.
- "No Smoking" signs will be placed in various locations to provide necessary warning.
- Fueling hoses and valves will be inspected regularly and repaired or replaced if necessary.
- Operators will be responsible for ensuring that vehicles being refueled or transferring fuel do not move until the operation is complete and all hoses and valves are secured.

4.4.3.5 Personnel

All personnel involved with petroleum products or hazardous materials will be instructed in spill prevention and control measures, as described in Section 4.11.

4.4.4 PESTICIDES AND HERBICIDES USE PLAN

There are presently no plans to use pesticides or herbicides on Tracts Ua and Ub. During construction, vegetation will be treated by mechanical means. After completion of the earthwork, it may be necessary to control vegetation in order to reduce fire hazards around the facilities. In this arid region, natural establishment of vegetation may be so slow and vegetated areas so sparse that mechanical control will suffice. However, should the growth of vegetation over extensive areas pose a fire hazard, mechanical control may have to be supplemented with periodic applications of herbicides. If the use of herbicides is warranted, the following procedures will be employed:

- The need for pesticide or herbicide use, the area of application, and the duration of treatment will be identified.

- An EPA-approved pesticide applicator will be engaged as required.

- The plan for pesticide-herbicide use will be submitted to the Area Oil Shale Supervisor for approval.

- The methods of application, storage, and disposal of pesticide-herbicide will be examined to ensure that they are in accordance with applicable state and federal regulations.

Garbage and kitchen wastes from employee support facilities will be confined to closed receptacles to prevent flies and similar pests from posing a substantial problem. In midsummer, during periods with little wind, biting midges can be very troublesome to man and animal, particularly in the vicinity of the White River, and it may be necessary to control these pests in localized areas to ensure continued productivity of the work force. Such application of insecticides will be cleared through the AOSS office.

4.5 WATER DRAINAGE AND EROSION CONTROL

4.5.1 DESIGN RATIONALE

Of the 10,240 acres on Tracts Ua and Ub, an area of approximately 2,325 acres will be directly affected by processing and disposal activities during the life of the White River Shale Project. Table 4.5-1 gives a breakdown of the acreage disturbed by the various construction and operation activities. Surface runoff and erosion control will be required for all of these areas and their contributing subdrainages.

The drainage system and erosion control concepts for the entire project will provide an integrated system of control and conveyance facilities designed to:

- Prevent contamination of the natural surface and groundwater systems
- Prevent or limit erosion of the terrain and reduce the need for extensive sediment retention
- Maximize the use of drainage waters for vegetation and project use

The principal areas for drainage consideration are the plant and process areas, the fines and sulfur stockpile area, the processed shale disposal areas, the hazardous waste disposal area, and the relatively undisturbed contributing drainage areas. All these principal areas will be affected during Phases I, II, and III and during decommissioning. Drainage will be controlled during each project phase by dams, culverts, ditches, stabilizing techniques, seepage control measures, surface grading, and revegetation.

Observations at the site have provided information on sediment transport. These observations, together with estimates obtained from the methods used by the U.S. Department of Agriculture (Soil Conservation Service), will be used to estimate the volumes of sediment that may be deposited in the various project impoundments. Limited data are presently available regarding the

Table 4.5-1

APPROXIMATE DISTURBED AREAS
(acres)

Type of Disturbance		Disturbed Areas				Treatment of Disturbed Areas[a]	
		Phase I	Phase II	Phase III	Total	Paved and Built-Over (Including Dam Pools)	Revegetated During Operation
Access Roads[b]		44	–	–	44	20	22
Utility Corridors[c]		11	31	–	42	–	42
Fines Stockpile (Phase I)		26	–	–	26	–	26
Processed Shale Landfill and Conveyance[d]		130	119	2,046	2,295	7	2,183
Phase I Dam[d,e]	Dam[f]	3	–	–	3	–	3
	Pool[f]	19	–	–	19	19	–
Southam Canyon Retention Dam[e]	Dam[f]	–	6	–	6	–	5
	Pool[f]	–	35	–	35	35	–
Process Site							
Tank farm		1	14	–	15	9	–
Tank farm emergency dikes		–	23	–	23	–	23
Wastewater holding basin	Dam[f]	3	–	–	3	–	3
	Pool[f]	6	4	–	10	10	–
Freshwater reservoir[e]	Dam[f]	–	4	–	4	–	–
	Pool[f]	–	9	–	9	9	–
Process pad, roads, buildings, sulfur product storage, etc.		44	138	138	320	75	12
Mining adits and shafts, stockpiles, changehouse, secondary crushing, etc.		8	10	1	19	16	3
Mine Vent Shafts and Excavation Landfill		–	3	<1	3	–	3
Total		295	396	2,185	2,876	200	2,325

(a) Figures in these columns do not equal "Total Disturbed Area" because some slopes may not be revegetated owing to fire hazards. Also, some areas revegetated during Phase I will be filled over during construction of Phases II and III.
(b) Areas for access roads include allowances for an electric utility line.
(c) Phase I 6-inch freshwater pipeline includes an allowance for an electric utility line.
(d) Phase I catchment is filled over during Phase II.
(e) Pool areas for all impoundments except freshwater reservoir are maximum design areas.
(f) Dam areas indicated are the areas left exposed when maximum design pool is impounded.

sedimentation characteristics of processed shale. The sediment storage volume required for each of the impoundments will be determined during project design. The volume of sediment in the impoundments will be monitored during the life of the project. If the sediment transport rate is found to be much higher than anticipated, the impoundments may be redesigned and the embankment raised to allow for adequate storage of sediment. Alternatively, the sediment could be dredged from an impoundment if it is found that the actual capacity is less than the design capacity. The dredged material would be removed to a location within the drainage basin and disposed of in a manner that would ensure that it will not be transported directly back to the impoundment.

Lease stipulations require that impoundments be of adequate size to retain the runoff from a 100-year flood. In developing the configurations of the drainage facilities, the 100-year flood was taken into consideration. Design of embankments classified as dams will be consistent with current dam engineering and safety practices in the United States.

The drainage control features for the raw shale fines stockpile area will be designed to minimize the amount of runoff that comes into contact with the stockpile. The design of the retention dam near the mouth of Southam Canyon will take into consideration the total area of the canyon's drainage basin. As the canyon is filled with processed shale, the contribution of filled areas to total basin runoff will decrease so that, at decommissioning, the dam storage capacity will exceed that required by the lease stipulations. The wastewater and storm runoff holding basin storage volume will be designed to meet the requirements specified in the lease. The freshwater reservoir's storage capacity will be sufficient to meet the requirements of project use, maximum storm drainage, and sedimentation for the life of the project.

4.5.2 DRAINAGE CONTROL PLAN

This section discusses the control of water movement during construction and operation, both on the ground surface and on and within the processed shale pile. Table 4.5-2 and Figure 4.5-1 summarize the control features of the drainage program. All catchments and impoundments will be designed to be relatively impermeable in order to minimize or prevent leaks and seepage. They will be monitored for leaks in accordance with the monitoring plan discussed in Section 6.3.

4.5.2.1 Processed Shale Disposal

Phase I. During Phase I, processed shale will be placed in a side canyon on the eastern slope of Southam Canyon, as discussed in Section 3.10. Surface and subsurface runoff from this shale pile will be intercepted by the Phase I dam built across the mouth of this side canyon. Small berms will be built if necessary in the northeastern part of the disposal area to ensure that contaminated flows are prevented from entering the unprotected drainage basin to the east. A 4:1 slope will be used to reduce erosion of the processed shale side slopes. A drain will be placed as required at the slope toes to carry drainage flows and to prevent erosion of the shale material. A significant portion (about 90 percent) of the natural drainage of Southam Canyon will not be interrupted. Storm runoff that does not contact the processed shale will continue to flow directly to the White River. Surface drainage from the processed shale will be controlled. The techniques involved are described in the discussion for Phases II and III.

If the project is abandoned at this stage, the surface contouring and revegetation procedures for erosion control discussed in Section 4.6 will be applied to the processed shale pile.

Construction of the Phase I dam located downstream from the processed shale pile will maximize the use of local materials. It will be built during construction of the Phase I facility, and it will provide sufficient capacity to contain the runoff of a 100-year storm from a drainage area of 300 acres.

Table 4.5-2

SUMMARY OF DRAINAGE CONTROL FEATURES

Feature	Location	Type	Drainage Area (acres)		
			Phase I	Phases II and III	Decommissioning
Phase I Dam[a]	Mouth of side canyon	Embankment	300	N/A	N/A
Southam Canyon Retention Dam	Mouth of Southam Canyon	Embankment	N/A	4,780[c]	200
Upper Southam Canyon Catchment Basin	South face of the processed shale pile	Embankment[d]	N/A	≈ 2,120[b]	≈ 2,120
Wastewater and Storm Runoff Holding Basin	North of plant site	Embankment	510	400	400
Freshwater Reservoir	South of plant site	Embankment	N/A	110	110
Processed Shale Vegetation Program	Surface of pile	Ridges and valleys	N/A	Variable	≈ 2,500
	Side slopes of pile	Side slope catchments	N/A	Variable	680
Fines Stockpile Area	Northwest of plant site	Embankments and culvert	250	250	250

(a) All dams will be built with sufficient capacity to satisfy lease stipulations and be commensurate with dam safety design practices in the United States.
(b) To be constructed after approximately 5 years of operation.
(c) Includes drainage area upstream of the Phase I dam.
(d) This feature is due to a layer of relatively impermeable material placed on the south face of the processed shale pile.

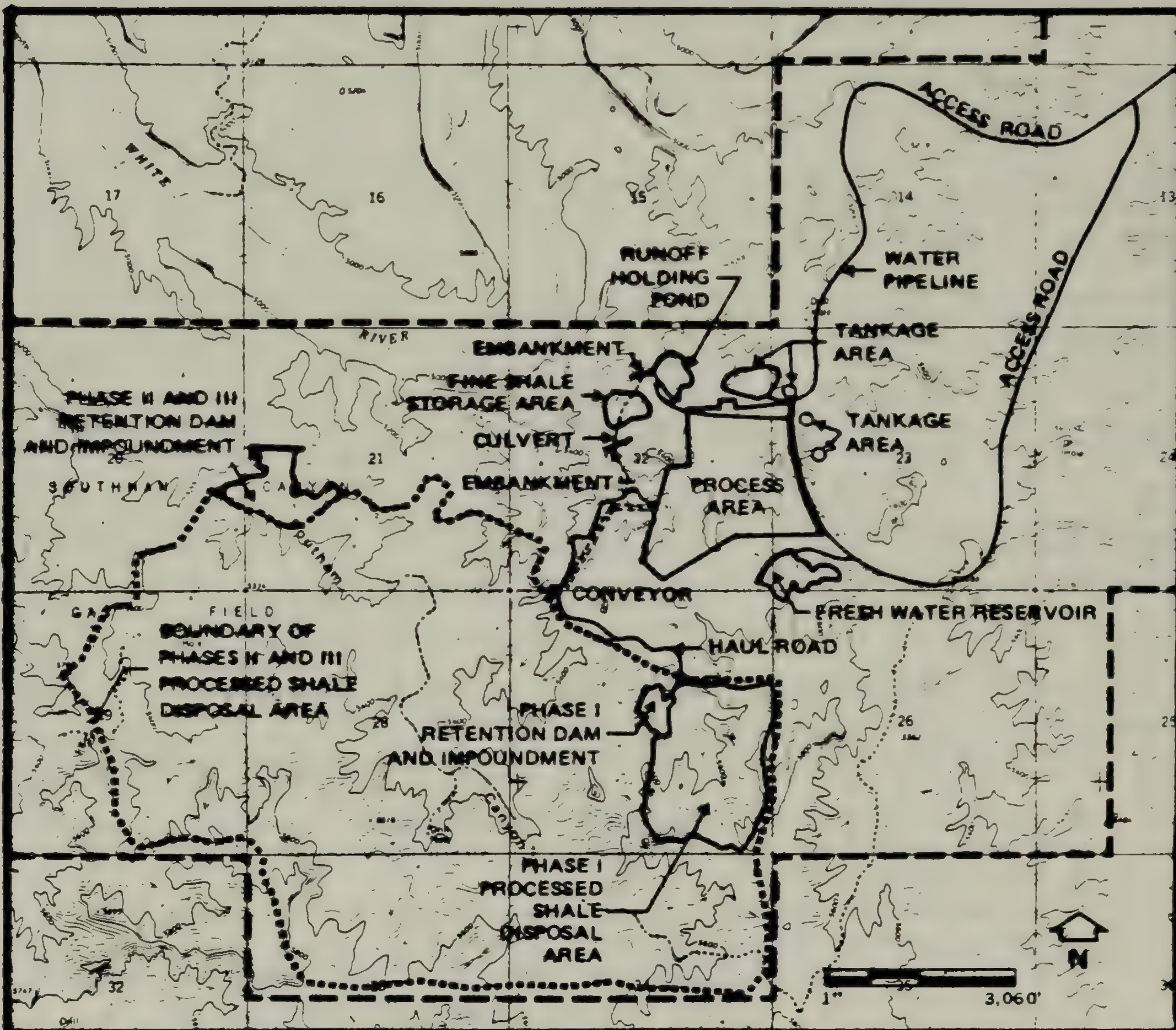

Figure 4.5-1 DRAINAGE CONTROL FEATURES

The dam will include a cutoff and foundation treatment to control seepage. The location of the dam will allow the uncontaminated runoff from the remainder of the drainage basin (5,010 acres) to flow to the White River. The dam will be abandoned when the project enters Phase II, because it will be covered subsequently by processed shale.

If the project is terminated before Phase II, however, the resulting drainage impoundment will then become an evaporation pond.

Phases II and III. In Phases II and III, disposal will proceed from the Phase I disposal site along the eastern ridge of Southam Canyon toward the southern limit of Tract Ua. In the early stages of Phase II, the main drainage channel in Southam Canyon will not be restricted by processed shale deposition in order to:

- Minimize runoff contamination
- Eliminate the need for additional drainage structures
- Ensure access to the alluvial materials for the revegetation program

To prevent contaminants from entering the White River, a retention dam will be built in the northern end of the canyon prior to the start of Phase II shale disposal. This dam will be an embankment-type structure consisting, insofar as possible, of local materials. The dam will include a cutoff and foundation treatment to control seepage underflow. As placement of the processed shale progresses across and down the canyon, a corresponding decrease in the effective drainage area of the dam will occur, continuing until completion of the project. Any drainage water captured behind the dam during the life of the project will be regularly pumped out and used in project activities such as dust suppression and compaction of the processed shale pile; standing water will be present behind the dam only for a short time after a major storm.

Surface runoff from the processed shale pile drainage will be controlled by two techniques. The first involves contouring the top surface of the finished process shale pile* into a series of small ridges and valleys that will retain precipitation. The second technique is to install catchment terraces on the slopes of the pile in order to capture rainfall in quantities up to 2.4 inches in 24 hours (100-year storm). These two techniques, part of the revegetation program (discussed in Section 4.6), are expected to nearly eliminate runoff from the finished pile.

The water falling on the finished processed shale pile will either infiltrate into the pile or be lost directly by evaporation to the atmosphere. The field capacity (i.e., moisture retention) of the processed shale is estimated to be about 20 percent by weight. The water applied for cooling and for dust suppression and compaction is expected to add about 10 percent by weight. Before water movement (percolation) could occur, the residual 10 percent of moisture would have to be provided by infiltration of precipitation. The processed shale below the uppermost 3 to 4 feet of the finished pile will be highly compacted and will have a low permeability, thereby retarding percolation past this depth. Moisture within the uppermost 3 to 4 feet will be evaporated to the atmosphere and transpired by the vegetation. Since the amount of annual potential evapotranspiration is several times greater than the expected annual precipitation, any excess moisture in the upper layer of the finished pile is expected to be consumed. Therefore, little, if any, water is expected to percolate through the entire depth of the finished processed shale pile.

Drainage from the upper portion of Southam Canyon will eventually be interrupted by shale disposal. A blanket of relatively impermeable local materials will be placed, as required, on the southern exposed slopes of the shale pile to retard the infiltration of surface runoff water from the

*The term "finished" is used to refer to any portion of the pile that has reached its final elevation.

off-tract portion of Southam Canyon into the shale pile. Any drainage water impounded by the impermeable layer behind the south face of the processed shale pile during the life of the project will be regularly pumped out and used in project activities such as dust suppression and compaction of the pile; standing water will be present behind the dam only for a short time following a major storm. At decommissioning, the uncontaminated water that will collect following rain storms will be allowed to evaporate.

Decommissioning. Decommissioning is discussed in Section 3.21.

4.5.2.2 Process Facility and Other Areas

General Erosion Control Methods. All construction and operations work will be conducted in accordance with applicable federal and state regulations and the directives of the Area Oil Shale Supervisor. Removal of vegetation will be limited to that which is absolutely necessary to prepare the construction sites, to provide an adequate work area, and to meet safety requirements for unobstructed vision. Vehicular traffic will be confined to roads, except in actual work areas, and driving in stream beds and/or on slopes after rains will be prohibited. Rehabilitation will be accomplished in all disturbed areas as soon as practicable. Rehabilitation methods are described in Section 4.6.

After construction, disturbed and highly erodible areas will be restored to conform to the general topography of the adjacent undisturbed land. Water bars will be installed on slopes to direct rainwater to vegetated areas and to minimize erosion. Topsoil will be stockpiled from all disturbed areas having suitable soils, and these areas will be revegated as soon as practicable after construction.

Drainage and Erosion Control — Process Area. Cutting, filling, and reshaping of the land will be done during construction of the process and tank farm areas. These activities will be accompanied by appropriate drainage

control measures: temporary diversions, interceptor ditches, berm shoulders, dikes, etc. These control measures will be built to prevent runoffs from eroding cut-and-fill slopes; water bars will be constructed to protect long slopes; and, where alternative sites are available, construction on steep slopes will be avoided.

Large portions of the process and tank farm areas will be built over an impermeable surface (see Table 4.5-1), and drainage control structures will be incorporated into the design of these areas. Downstream from the process and tank farm areas, an embankment-type dam will be constructed at the beginning of Phase I. The holding basin of the dam will be designed to contain the following: 1) 110 percent of the largest tank plus displacement of all other tanks in the compound below the dike height or liquid level, plus 2) a volume sufficient for maximum trapped precipitation and runoff that might be impounded at the time of a spill. The earthen dike will have a flat surface 3 feet wide on top of the dike.

The dam will include a cutoff and foundation treatment and an impermeable lining to limit seepage underflow. At the start of Phase II, the dam crest will be raised and the basin excavated to accommodate the increase in tankage and wastewater volumes as required.

The freshwater reservoir south of the process area will be of value in runoff and erosion control. Its principal purpose will be to provide on-tract storage of freshwater. At decommissioning, the reservoir will become an evaporation pond.

The raw shale fines produced during Phase I will be stockpiled and processed gradually during Phase III. The stockpile will be placed on a bed of relatively impervious local materials to minimize infiltration of leachate. Two embankments (immediately upstream and downstream of the stockpile) will be constructed along with a culvert system to divert the upstream runoff

past the stockpile and avoid contamination by the raw shale fines. The upstream embankment will cause runoff to enter the culvert system, which will pass the water underneath the stockpile and through the downstream embankment. From this point, the water will be allowed to flow to the White River via the small tributary north of the plant site. Surface runoff from the plant site will be directed toward the wastewater holding basin and will not be allowed to enter the drainage upstream of the fines stockpile. The embankment immediately downstream of the fines stockpile will intercept contaminated surface runoff from the storage site. This water will be collected for use in process activities such as dust suppression.

Raw shale stockpiles will be placed on a bed of relatively impervious local materials to minimize infiltration of the leachate. Berms will intercept contaminated surface runoff from these storage sites and will be collected for use in project activities such as dust suppression and compaction of the processed shale pile.

Drainage and Erosion Control — Pipelines and Roads. During clearing operations for the water and product pipelines, vegetation will be shredded, and left on the soil surface. The cleared right-of-way will be wide enough to accommodate the pipe trench and to provide a suitable work area for pipelaying operations (probable width of 25 to 65 feet). Grading of the right-of-way may be required to make the work area safe, particularly on severe slopes. The rate of clearing and grading will be coordinated with ditching, pipelaying, and backfilling operations to minimize the amount of disturbed (and hence erodible) land.

Because of the rocky terrain, backfilling the trench (after pipelaying) with a carefully selected combination of materials may be required. Suitable materials may be secured on tract or brought in from off tract. To reduce the likelihood of erosion, backfill material will be compacted to a density

approximately equal to its density before excavation. Alternatively, a mound of backfill material may be left over the ditch to compensate for natural settling and compaction. Runoff diversion devices will be placed where needed on slopes to keep the backfill from being washed away. Upon completion of pipeline work, loose and unconsolidated material (which is subject to erosion) will either be compacted or removed from the right-of-way.

Drainages that will be crossed by the pipelines on tract are small and flow infrequently. Whenever possible, pipeline construction will be carried out in dry periods when the crossings can be made by the open-trench method.

Roads will be designed to allow storm runoff to follow the natural drainage courses as closely as possible. Culverts will be built under the new roads at natural drainage points to prevent water blockage. Culvert sizes will be chosen by taking into account the natural drainage's maximum expected flow rate resulting from a 100-year storm. In the upgrading of existing roadways, natural drainage will be maintained by constructing additional culverts, where necessary.

Normal roadbuilding materials will be employed. To minimize the likelihood of leaching of objectionable materials, the choice of road-building and maintenance materials will depend on where these materials will be used.

Rehabilitated surfaces in the pipeline and road easements will be stabilized and revegetated, as appropriate, as discussed in Section 4.6.

4.5.3 SURFACE AND SUBSURFACE DRAINAGE INTERACTION

Available data suggest that it is unlikely that the Bird's Nest Aquifer could be detrimentally affected by leachate from the processed shale, seepage from on-tract impoundments, or mining operations. A monitoring program (discussed in Section 6.3) will be implemented to detect any

changes. The Bird's Nest Aquifer is confined and under artesian conditions within Tract Ua. Analysis of pumping test data indicates that the overlying confining materials have very low permeability. Moreover, when the overylying materials were drilled, they were dry and no water was encountered until the Bird's Nest Aquifer was penetrated (except at the P-2 location where an aquifer of limited areal extent exists near the contact of the Uinta and Green River Formations). These data furnish good evidence of the relative impermeability of the overlying materials. These materials act as a confining layer that restricts upward movement of water from the Bird's Nest Aquifer and retards downward movement from higher layers.

Seepage of contaminated surface runoff into the alluvial materials will be restricted, through design features of the dams, to that portion upstream from the catchment dams. Cutoff walls will be built through the alluvial materials to prevent any such seepage from moving downstream to the flood plain of the White River.

Some dewatering will be required during mining operations, but it is expected to be minimal. The removal of oil shale could result in permanent changes in the structure of the aquifer-aquiclude materials, but these changes are expected to be very slight.

When the oil shale is removed, subsidence (however small) could cause physical changes in the overlying materials. The extension of the overlying materials into the mined zone and the resulting tension fracturing would tend to increase vertical permeability between the Bird's Nest Aquifer and the mined zone. Although this is not expected, the possibility of subsidence has been recognized and evaluated. There is only a remote possibility of increased permeability through release of confining stress in the underlying materials.

If subsidence due to mining were to reach the ground surface, it should be very slight and relatively uniform over Tracts Ua and Ub, considering the

depth of the mined zone and the expected minimizing of subsidence in the final pillar and mine design parameters. Nevertheless, surface subsidence will be monitored.

4.6 DISTURBED AREA REHABILITATION AND REVEGETATION

Section 11(L) of the Oil Shale Lease Environmental Stipulations states the following:

> The Lessee shall revegetate all portions of the Leased Lands which have been disturbed by his operations as soon as possible after the disturbance has ended in order to prevent, or, if prevention is impracticable, to minimize erosion and related problems. The lessee shall restore the vegetation of disturbed areas by reestablishing permanent vegetation of a quality which will support fauna of the same kinds and in the same numbers as those existing at the time the baseline data was obtained under section 1(C) of these Stipulations.

This section describes the program developed by the White River Shale Project to comply with these stipulations.

4.6.1 REHABILITATION PLAN FOR DISTURBED AREAS

During peak construction and operation periods, approximately 600 acres of land on Tracts Ua and Ub (excluding the processed shale disposal site) will be disturbed. Of this total, permanent structures, road surfaces, reservoir surfaces, and areas that must remain clear of vegetation to avoid fire hazards will cover approximately 200 acres. The remaining disturbed area, approximately 400 acres, will be rehabilitated by restoring the land, as nearly as possible, to its natural state or to an appropriate productive state. Rehabilitation activities will include site cleanup and, where necessary, surface preparation and revegetation.

Land rehabilitation will begin soon after construction activities cease. Trash, garbage, leftover construction materials, and other debris will be removed to a landfill or appropriate disposal sites. After cleanup activities, the surface will be prepared, critical areas will be stabilized, and vegetation will be reestablished through direct seeding or transplanting. In some locations, simple cleanup should suffice to restore the area to its natural state. (This might be lightly used areas where the vegetation has

not been badly damaged and the soil has not been significantly disturbed.) Revegetation will not be attempted in rocky areas devoid of topsoil, or in areas where natural vegetation cover does not now exist.

In more severely disturbed locations, especially those where existing vegetation and topsoil have been removed, an intensive revegetation program will be implemented. Where the land has been only moderately disturbed, an intermediate program of revegetation will suffice to restore the land to a productive state. The degree of effort required to rehabilitate each disturbed location will be determined case by case.

4.6.1.1 Steps in Rehabilitation of Disturbed Areas

Elements of the rehabilitation program for severely disturbed land areas are described below.

Treatment of Vegetation. Because of construction requirements, the aboveground portions of all woody plants will be shredded and left in place in the areas to be disturbed. Thus, the shredded plant material will be left on the topsoil to be used as mulch in the future.

Removal of Topsoil. Where excavation or other severe disturbance is planned and the excavated material is unsuitable for supporting vegetation, the existing topsoil will be removed. Wherever possible, topsoil and mulch will be scraped off and stockpiled. After construction is completed, the stockpiled topsoil will be redistributed over the surface.

Seedbed Preparation. Seedbeds will be prepared with disks, disk harrows, rollers, or other suitable implements, wherever practicable. The goal will be to prepare a surface that is firm, finely divided and free of weeds.

Mulch. Where vegetative debris was shredded, it will be applied to the surface as a mulch. Straw or native hay mulch will be used if vegetative debris is insufficient.

Stabilization. Critical areas (i.e., those with potential erosion problems or high visibility) will be stabilized by applying a suitable mulch cover immediately after construction has ended. Mulch with a minimum of weed seed will be preferred. This mulch will be held in place by punching, disking, or applying a tacking compound. Experiments will be performed in limited areas to determine the feasibility of using annual oat, rye, or barley for initial soil stabilization, and then seeding the permanent species mixture into the remaining stubble. Due to the low rainfall of the tracts and the high water demand of these cereals, it is not anticipated that such a program would be successful except in highly favorable areas.

Fertilizer. Soils deficient in nutrients will be fertilized. The need for fertilizer will be determined by site-specific soil testing.

Seeding. Seeding will be scheduled for late fall to take advantage of winter moisture accumulation for growth in early spring. In addition, many seeds require winter chilling or scarification before they can germinate, seed-collecting animals are less active during the winter, and historically, fall seeding gives the best results in this region. Generally, each site will be seeded in the first fall following construction.

Drill seeding will be used wherever seeding equipment can safely operate, primarily in open areas prepared for seeding. In order to seed openings in the vegetation to increase plant density and cover for wildlife habitat improvement in selected areas, a small interseeding implement mounted on a 3-point hitch behind a wheel tractor will be used. Seed placement will be to depths of 1/2 to 3/4 inches in 6- to 8-inch rows. Broadcast seeding

will be used only in areas that are inaccessible to drills. Following broadcase seeding, the seeds will be covered by light chaining or raking or some other suitable method as appropriate to the site.

A typical seeding rate is 20 to 25 pure live grass seeds per square foot (or approximately 1 million seeds per acre). Shrubs will be seeded at the rate of 1 to 5 pounds per acre depending on the species. In critical areas and in areas where broadcast seeding must be used, these rates will be doubled.

Plant Species Selection. Plant species will be selected for seeding that are adapted to climatic conditions of the area, that will be useful in controlling soil erosion, and that will provide grazing for big game and livestock. The mixture will consist of several grass and shrub species selected from the following list as available:

Nordan Crested Wheatgrass	*Agropyron desertorum*
Pubescent Wheatgrass	*Agropyron trichophorum*
Intermediate Wheatgrass	*Agropyron intermedium*
Russian Wildrye	*Elymus junceus*
Western Wheatgrass	*Agropyron smithii*
Needle-and-Thread	*Stipa comata*
Squirreltail	*Sitanion hystrix*
Indian Ricegrass	*Oryzopis hymenoides*
Douglas Rabbitbrush	*Chrysothamnus viscidiflorus*
Rubber Rabbitbrush	*Chrysothamnus nauseosus consimilis*
Spreading Rabbitbrush	*Chrysothamnus linifolius*
Black Sagebrush	*Artemisia nova*
Big Sagebrush	*Artemisia tridentata*
Fourwing Saltbush	*Atriplex canescens*
Cuneate Saltbush	*Atriplex cuneata*
Winterfat	*Ceratoides lanata*

Seeds used for revegetation will meet the quality standards of the Federal Seed Regulations. Certified named varieties, when available, will be used in preference to others. Seeds of commercially unavailable native shrubs will be obtained from seed collectors under contract for collection from the general area of the oil shale tracts or ecologically equivalent areas.

Grazing. Grazing of livestock will not be permitted until plants are well enough established to survive grazing and trampling. Arrangements will be made with the Bureau of Land Management and stockmen to keep livestock out of seeding areas or a fence will be erected around each area.

If necessary, the revegetated areas will be protected from mule deer grazing by using repellents, sound systems, or deer fencing. Repellents and/or other effective means may be required to control small mammals if damage due to these animals reaches sizeable proportions.

Test Results. During the 4-year revegetation research program, results from direct seeding have been inconclusive. Due to uncertain drought conditions during the critical spring period of seedling establishment, direct seeding attempts between 1974 and 1979 were virtual failures. However, some seedings along a Gilsonite pipeline about 15 years ago by Bureau of Land Management personnel gave limited success. Increased seeding establishment may be obtained in critical areas by repeat seeding and mulch application. Further studies may be conducted to improve current methodology for local use.

4.6.2 REVEGETATION PLAN FOR PROCESSED SHALE

Revegetation of processed shale on Tracts Ua and Ub presents unique problems. This is due to the harsh characteristics of the arid environment, which is hot in the summer and cold in the winter, and to the limitations of processed shale as a plant growth medium. These problems are compounded by

the limited amounts of soil available for covering the shale pile and practical constraints on the use of water for leaching and irrigation to ameliorate the harsh conditions. For revegetation to be successful, these constraints must be understood in detail and the revegetation plan must be designed to take them into account.

To determine those properties of the processed shale that affect plant growth and to generate information on specifics of the White River Shale Project processed shale, a preliminary inquiry was made on the processed shale characteristics. The three major determinants of processed shale characteristics are: the retorting process, the temperature of retorting, and the composition of the raw shale.

Since typically processed shale from Tracts Ua and Ub was not available for testing, no direct evidence of its characteristics can be presented. However, to obtain preliminary information on the nature of plant responses where grown on processed shale, samples of Colorado and Utah shale processed by Paraho at Anvil Points, Colorado were analyzed and evaluated in laboratory and field studies. This shale is expected to be physically and chemically similar to processed shale from Tracts Ua and Ub.

4.6.2.1 Physical Properties of Processed Shale

The physical properties of processed shale that affect plant growth include texture, field moisture capacity, permeability, temperature, and resistance to wetting.

Texture. Processed shale is a coarse-textured residual material that remains after retorting. It is gravelly silt loam to silt-gravel in texture, with soil size particles (less than 2 millimeters in diameter) ranging from 10 to 40 percent by weight in fresh samples. Compaction and weathering have been shown to be very effective in reducing the number of large particles and in increasing the moisture holding capacity and the cation exchange capacity of the shale (Ref. 4-12).

Field Moisture Capacity. Field moisture holding capacity of the soil sized particle of processed shale is approximately 20 to 22 percent by weight, and may be increased by weathering of larger shale particles.

Permeability. Because of its coarse texture, it is expected that the Paraho processed shale will have high permeability (1 to 2 inches per hour), which can be reduced considerably by compaction.

Temperature. Surface temperature of the processed shale pile is expected to decrease from extremes of over 120F to values roughly equal to adjacent soil surface temperatures as the original dark color weathers to a gray after two or more seasons of exposure to wetting and drying and freezing and thawing.

Resistance to Wetting. Paraho shale samples have little resistance to wetting unless the retorting process is not complete.

4.6.2.2 Chemical Properties of Processed Shale

The chemical properties of processed shale that affect plant growth include salinity, ionic composition, boron, cation exchange capacity, and presence of plant nutrients. Table 4.6-1 compares the chemical properties of Paraho processed oil shale from Colorado and Utah with those of Union Oil Co. processed oil shale from Utah, unprocessed oil shale from Utah, and top soil from a shadscale community on Tract Ua.

Salinity. Electrical conductivity (EC) values of several Paraho-processed shale samples range from 5 to 22 mmho/cm for the saturation extracts in Table 4.6-1. It is expected that salinity of processed shale from Tracts Ua and Ub will also be in this range. Salinity generally affects sensitive plants when the electrical conductivity of the saturation extract exceeds 4 mmhos per centimeter. Plants of higher salinity tolerance can grow when EC values range from 4 to 8 mmhos/cm. Saltbush species, however, are much more tolerant of high salinities. Four native species have exhibited no difference in growth on shale over a range of EC values from 8 to 17 mmho/cm.

Table 4.6-1

CHEMICAL PROPERTIES OF OIL SHALE

Type of Shale/Soil	pH	EC mmho/cm	Me/100 g based on 1:1 extract								ppm					
			Na	K	Ca	Mg	SO_4	Cl	HCO_3	CEC	B	P	NO_3	K	Fe	Zn
Paraho Colorado #1	9.0	17.1	6.9	0.6	1.4	1.9	11.1	0.1	0.2	4.8	0.7	4.4	0.3	290		
Paraho Colorado #2	9.0	10.6	4.0	0.1	0.7	2.8	5.2	0.04	0.2		0.9	1.7		102		
Paraho Colorado #3	9.3	19.0	5.3		0.5	1.8	9.0	0.04	0.1			5.2	0.3	460	61	13.4
Paraho Colorado #4	9.0	22.0								5.1	0.5	3.8	0.4	480	49.2	8.4
Paraho Colorado #5	10.8	9.8	3.0		0.7	0.1					1.5				46	0.5
Paraho Utah Shale	11.7	5.2	1.3	0.3	0.6	0.01	1.5	0.2	0.7		0.2					
Union Utah Shale	8.2	8.0	2.0	0.1	2.3	3.7	3.8	0.3	0.2							
Raw Utah Shale	7.7	3.2	0.8							1.8	10.8	1.5	6.1	70		
Soil Bs-4	7.5	1.7	5.8	0.2		3.3						2.1				
Leached Paraho Colorado #2	7.7	3.6										0.6		45		

(a) Analysis is for a depth of 8 to 14 cm Bs soil typical of the Southam Canyon floor as reported in the Final Environmental Baseline Report (Ref. 4-15). Chemical analyses were performed by the Utah State University Soils Laboratory.

Growth was reduced by only 17 to 61 percent, depending on the species, when EC increased to 31 mmho/cm. Growth of three of these species was actually enhanced by the addition of salt to leached processed shale or low salinity soil (Ref. 4-13).

Fransway (Ref. 4-14) has shown that the salts in processed shale are readily leached. If leaching were necessary, the addition of about 2 pore volumes of water (about 22 percent of the shale is pore space) would reduce the salinity level in the upper 60 cm of spent shale to a condition not detrimental to most plant species. However, use of salinity-tolerant plants would require little or no leaching. If salts are leached to depths greater than 60 cm, there is little likelihood of upward salt migration.

Ionic Composition. The dominant salts in Paraho-processed oil are sodium, magnesium, calcium, and sulfate. The mixture of salts in leachate from processed shale was less harmful to plant growth than pure sodium, magnesium sulfates, or sodium chloride when added to leached processed oil shale to produce a range of salinities (Ref. 4-13).

Boron. Boron ranged from 0.2 to 1.5 ppm in several Paraho-processed shale samples analyzed at Utah State University. The higher values may be at toxic concentrations for some crop species but, from field observations and salinity measurements, not for most salt desert plant species.

Cation Exchange Capacity. Cation exchange capacity of a soil is indicative of the rate at which a soil will supply nutrients to plants. Processed shales appear to have low cation exchange capacities, and it is expected that the White River shale will also have low cation exchange capacities.

Major Plant Nutrients. Nitrogen, phosphorus, and potassium are the three major plant nutritional elements that are routinely assessed in fertility determinations of soils. It is expected that the processed shale will be deficient in nitrogen and phosphorus but will contain adequate amounts of potassium.

4.6.2.3 Biological Properties of Processed Shale

Chemical processes that take place in a soil, the availability of nutrients, and to some extent the existence of higher plants, depend on the biological activities of the soil. The populations of soil microbes are determined principally by the soil's organic matter content. Processed shale leaving the retort has neither microbes nor organic matter, and unless organic matter is supplied to it, microbial activity will not start for a long time. The solution to this problem is to apply topsoil to the disposal pile.

4.6.2.4 Availability of Soil for Covering Processed Shale Pile

The baseline soil survey identified four soils and their complexes within the processed shale disposal site. Figure 4.6-1 is a soil map indicating the locations of these soils. Classification, textural name, depth, and acreage of these soils is given in Table 4.6-2. The soils indicated by map symbols "A," "As," and "B" occupy the largest portion of the site. "A" soil is a shallow channery loam; "As" soil is a shallow channery sandy loam; and "Bs" soil is a very shallow channery and flaggy sandy loam. These soils are located on moderate to steep slopes (5 to 50 percent) and have a moderate to high erosion hazard.

All of these soils contain considerable amounts of rock fragments. For the A soil, rock fragment content is estimated at 25, 50, and 80 percent at 0 to 2.5, 2.5 to 8, and 8 to 18 inch depths, respectively.

D soil, the only deep soil of the area, is a sandy loam that occupies alluvial drainage ways below steep slopes and rock outcrops. Forming in alluvium from the Uinta Sandstone, this soil is strongly calcareous, alkaline in patches, and moderately permeable, and it contains approximately 15 percent rock fragments. Although its depth to the bedrock is not known, it is not less than 5 feet. However, salinity increases considerably at depths below 44 inches (113 cm) and below that depth the soil would generally not be a suitable plant growth medium.

LEGEND:*

DEEP SOIL DEPOSITS (SOIL TYPE D) SUITABLE FOR USE IN THE REVEGETATION PROGRAM

BARE ROCK

SHALLOW OR POOR QUALITY SOILS

SOIL	LIMITATION	NOTE
A	SHALLOW STONY	
B	SHALLOW STONY	
N	SALINE AKALI	①
E		①
F	SHALLOW SANDY	①
W		①

ls on soil types see chapter 2.2-7 and
vey of Utah Oil Shale Tracts U-a U-b and
" in the First Year Environmental
Report (Ref. 5).

ls will not be affected to any appreciable
n tract construction.

Figure 4.6-1 MAP OF SOILS IN THE TRACTS AND VICINITY

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The baseline soil survey identified four soils and their complexes within the processed shale disposal site. Figure 4.6-1 is a soil map indicating the locations of these soils. Classification, textural name, depth, and acreage of these soils is given in Table 4.6-2. The soils indicated by map symbols "A," "As," and "B" occupy the largest portion of the site. "A" soil is a shallow channery loam; "As" soil is a shallow channery sandy loam; and "Bs" soil is a very shallow channery and flaggy sandy loam. These soils are located on moderate to steep slopes (5 to 50 percent) and have a moderate to high erosion hazard.

All of these soils contain considerable amounts of rock fragments. For the A soil, rock fragment content is estimated at 25, 50, and 80 percent at 0 to 2.5, 2.5 to 8, and 8 to 18 inch depths, respectively.

D soil, the only deep soil of the area, is a sandy loam that occupies alluvial drainage ways below steep slopes and rock outcrops. Forming in alluvium from the Uinta Sandstone, this soil is strongly calcareous, alkaline in patches, and moderately permeable, and it contains approximately 15 percent rock fragments. Although its depth to the bedrock is not known, it is not less than 5 feet. However, salinity increases considerably at depths below 44 inches (113 cm) and below that depth the soil would generally not be a suitable plant growth medium.

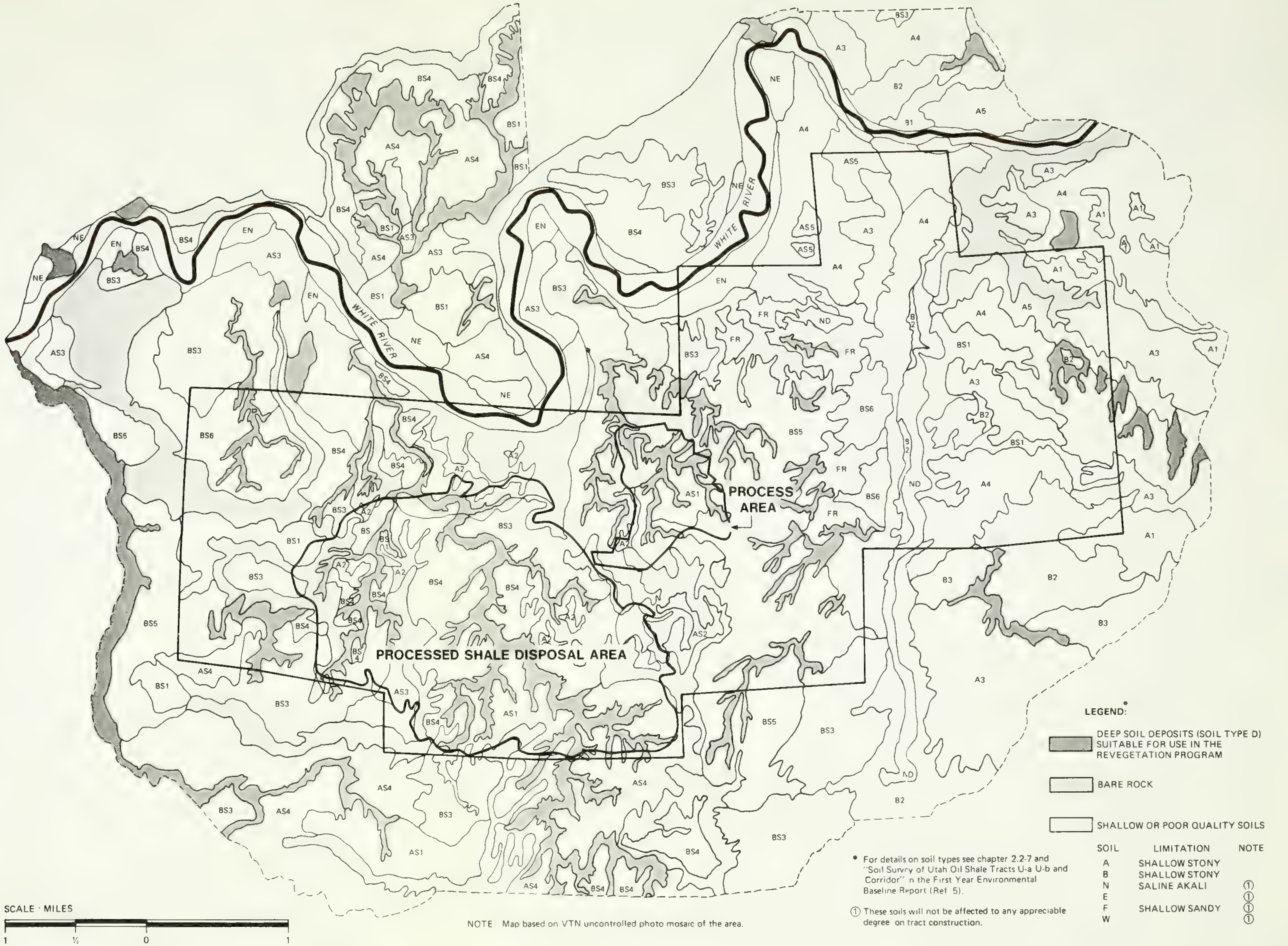


Figure 4.6-1 MAP OF SOILS IN THE TRACTS AND VICINITY

Table 4.6-2

SOILS OF THE PROCESSED SHALE DISPOSAL SITE

Map Symbol Subgroup USDA SCS 1973 Classification[(a)]	A Lithic Calciorthids	A Lithic Calciorthids	Bs Lithic Torriorthents	D Typic Torrifluvents	R
Soil Texture	Shallow channery loams	Shallow channery sandy loams	Very shallow channery and flaggy sandy loams	Sandy loams	Rockland
Depth, inches	12 to 20	12 to 20	2 to 10	60+	
Acreage in Disposal Area	95	652	737	453	358

(a) Soil Taxonomy, 1973, United States Department of Agriculture, Soil Conservation Service, Washington, D.C.

The area classified as R (rockland) has no appreciable amount of soil.

Soil required for revegetating the processed shale will be obtained primarily by removing D soil from Southam Canyon in increments and stockpiling it prior to disposition of the processed shale; A and As soil may also be used where suitable. If only D soil is used and if it is scraped down to the saline layer of 44 inches, there will be enough soil to cover the entire shale pile to a depth of 8.6 inches. This depends to a degree on the total area to be revegetated. If, in addition, the A and As soils are used to a depth of 10 inches, the shale pile can be covered to a depth of 9.8 inches. This soil depth is not sufficient for rapid establishment of shrubby plants, but if soil is concentrated over 1/4 of the surface (in trenches), the soil depth would be adequate (34 to 39 inches).

4.6.2.5 Revegetation Plan

By the end of operation of the White River Shale plant, approximately 2,300 acres in Southam Canyon will be covered by processed oil shale. Establishing and maintaining vegetation on this area represents a sizeable challenge in view of the characteristics of the processed shale and the limitations of the availability of water and suitable topsoil. In order to develop a workable revegetation technology, a research program was undertaken by the White River Shale Project using the Utah State University Agricultural Experiment Station under the management of the Institute of Land Rehabilitation. One of the components of the research program was a study of water harvesting potential from short slopes created on the surface of the processed shale disposal pile. Results show that by applying a soil stabilizing material to short collecting slopes, it is possible to harvest from 40 to 55 percent of the precipitation falling on the surface and concentrate it in an area at the base of the slope (Ref. 4-16).

The White River Shale revegetation plan which follows is based on the findings of several studies (Ref. 4-12). It should be emphasized that this plan is not final and that research alternatives will continue to be tested and evaluated until an optimum program is defined.

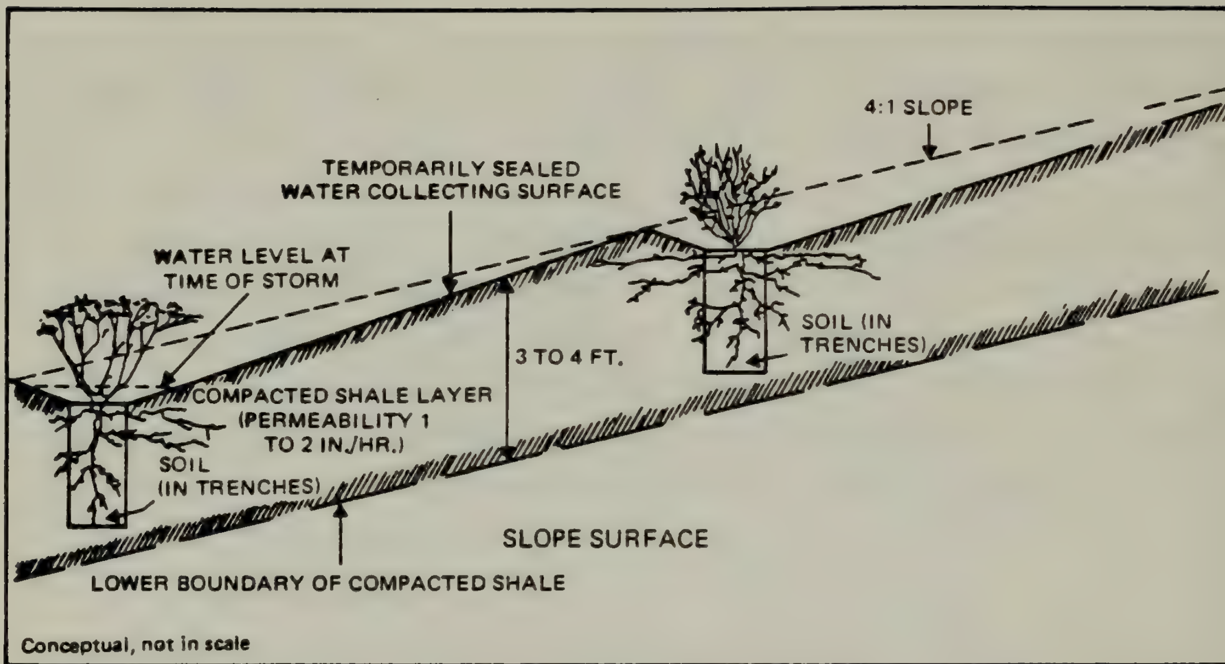
Steps in the rehabilitation program for processed shale are outlined below.

Removal of Vegetation. Existing vegetation will be removed in front of the advancing processed oil shale disposal pile except where slopes are too steep to operate equipment. The vegetative material will be saved and shredded for use as a soil amendment.

Excavation of Topsoil. D soil (alluvium) may be removed to a depth of about 44 inches (113 cm) in front of the advancing shale disposal pile. Alluvium becomes too salty below this depth. Other alluvial or residual soil materials will also be removed if they are not too thin and rocky. When possible, the soil material will be placed directly on a completed spoil pile, but in some instances it may be necessary to stockpile it. The stockpiled soil will be planted to stabilize the pile to maintain biological activity. Planned use requirements will determine how much soil will be removed.

Terracing. The processed shale will be shaped into water-harvesting slopes and terraces and the 3- to 4-foot surface layer will be crushed and compacted. Phosphorous fertilizer and organic matter (shredded vegetation) will be tilled into the top 6 inches of the processed shale pile; and a trench will be dug in each terrace and filled with soil (Figure 4.6-2). Processed shale excavated from the trench will form a berm on the downhill side of the terrace. The resulting planting basins will be capable of holding runoff from a 100-year storm. Soil will be concentrated in trenches to provide sufficient depth for rapid initial establishment of transplanted shrubs and reintroduction of biological activity (soil fungi, bacteria, invertebrate seeds, etc.).

Stabilization. Slopes for water harvesting will be treated with a chemical stabilizing material to reduce wind and water erosion and to promote water harvesting. Possible choices for soil stabilizing agents include polyvinyl acetate (PVA), styrene butadiene latex (SBR), and paraffin at appropriate



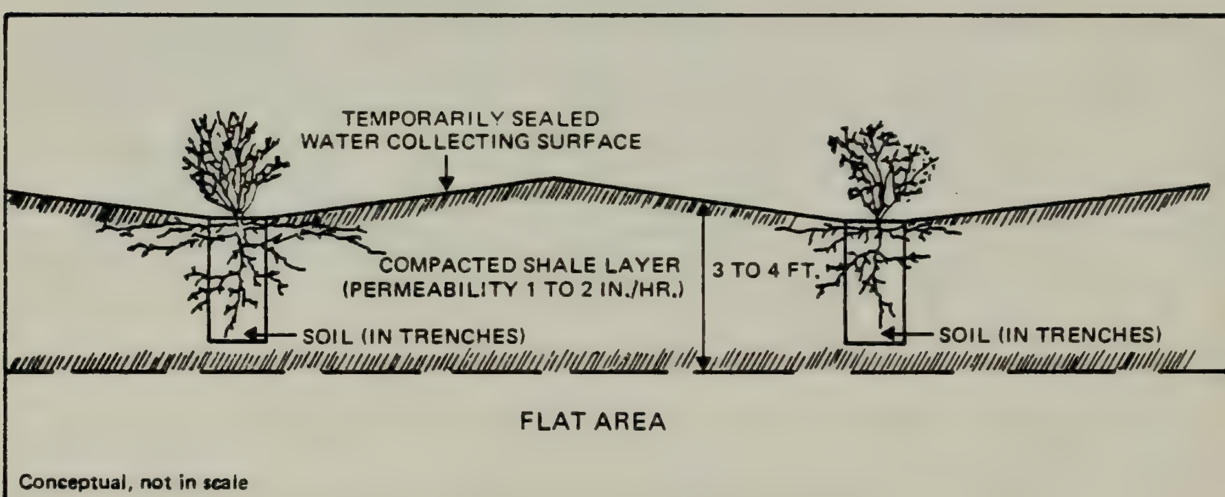


Figure 4.6-2 SURFACE MODIFICATION AND VEGETATION ON PROCESSED SHALE

application rates (Ref. 4-17). Other alternatives are being investigated for more cost effective materials. Harvested water will enhance soil moisture in the soil trench and promote growth. Chemical stabilizers are expected to gradually break down after a year or two so as not to inhibit plant colonization of the processed shale slopes.

Plant Selection. Soil moisture will be allowed to accumulate over the winter, and container-grown or bare-root plants will be transplanted into the soil trenches in the spring. Prior to planting, the soil trench will be fertilized with nitrogen and phosphorus based on soil analyses. Plant species will be selected for seeding that are adapted to the climatic conditions of the area and that are tolerant of high salinities. Possible plants to be used include:

Fourwing Saltbush	*Atriplex canescens*
Shadscale	*Atriplex confertifolia*
Mat Saltbush	*Atriplex corrugata*
Cuneate Saltbush	*Atriplex cuneata*
Garner Saltbush	*Atriplex gardneri*
Greasewood	*Sarcobatus vermiculatus*
Winterfat	*Ceratoides lanata*
Hop Sage	*Grayia brandegei*
Hop Sage	*Grayia spinosa*
Summer Cypress	*Kochia americana*
Prostrate Kochia	*Kochia prostrata*

Seeding. Seeds from plants in the soil trenches will fall upon or be wind blown upon the shale slopes. Salt tolerant plant species will be the first to colonize the shale slopes, but less salt tolerant species are also expected to invade the slopes as salts are gradually leached from the shale surface. After plants are well established in the soil trenches, colonization of the shale slopes may be enhanced by roughening (furrowing or harrowing) the shale slopes, adding nitrogen fertilizer, and spreading a limited amount of topsoil.

Livestock Grazing. Emerging young plants are highly palatable, and grazing animals tend to concentrate on revegetated land. Thus, grazing by livestock will not be permitted until plants become well established and are able to resist a moderate degree of defoliation and trampling. The revegetated areas will be protected from livestock grazing by:

- Making arrangements with the stockmen and/or Bureau of Land Management leaseholders to keep the livestock out of the area until the area can be grazed, or

- Erecting a fence around the revegetated area (Electric fencing or similar economical and effective fencing methods will be used, if necessary.)

Big Game Grazing. Grazing big game on the tract is limited to occasional mule deer. If necessary, the revegetation area will be protected from mule deer by using repellents, sound systems, or, as a last resort, deer fencing. The tract is also inhabited by a number of small mammals that can attack and seriously damage new plantings. If damage due to these animals reaches sizeable proportions, repellents and other acceptable control techniques would be applied.

Revegetation Schedule. Phase I operation will result in a processed shale pile covering an area of about 130 acres with some sloping surfaces. It is planned that the flat surface of this pile, or a portion of it, will serve as a demonstration area for revegetation techniques. At the end of Phase I, the entire flat surface will be revegetated and at this point, if a decision is made to decommission the White River Shale project, the entire pile, including the slopes, will be revegetated. After completion of Phases II and III, approximately 2,300 acres of Southam Canyon will be covered with processed shale. Assuming that the volume of processed shale is proportional to the final surface of the pile, an average of about 115 acres per year for each of 20 years will require vegetation. Revegetation will follow processed shale disposal as closely as possible.

4.7 FISH AND WILDLIFE MANAGEMENT PLAN

The objective of the Fish and Wildlife Management Plan is to establish procedures for the protection or restoration of the fish and wildlife habitat on the tracts. These are to be in accordance with Section 4 of the oil shale lease environmental stipulations. The plan identifies steps to be taken to avoid or minimize damage to fish and wildlife habitat and water supplies, to restore habitat that is unavoidably destroyed or damaged, to provide alternative habitat, and to provide controlled access by the public. The plan will be implemented just prior to Phase I construction and will be discontinued after complete restoration when the project is decommissioned or abandoned. The details of the plan and the schedule for implementation will be developed in response to factors such as:

- The results of the 2-year baseline study and extended monitoring programs
- The intensity of habitat disturbance during each phase of the project
- Any relevant shifts in land-use patterns or priorities, such as hunting or grazing

When the dam on the White River is constructed by the state of Utah, the management plan will be coordinated with the fish and wildlife management plan developed for the dam. The details of the design and implementation of the plan will be developed in cooperation with the Area Oil Shale Supervisor's office and in response to guidance from the state of Utah Division of Wildlife Resources, the U.S. Bureau of Land Management, and the U.S. Fish and Wildlife Service.

4.7.1 AVOIDANCE OR MINIMIZATION OF DAMAGE TO FISH AND WILDLIFE HABITAT

A primary consideration in the conceptual planning for the project, as presented in the DDP, has been to select from the variety of available alternatives an overall facility and operational design that minimizes the loss of or damage to fish and wildlife habitat. The analysis of alternatives is presented in Section 7.

The balancing of environmental, economic, and other considerations has resulted in a facilities layout that will remove only a small acreage of the riparian and shadscale habitats. The disposal of processed shale in Southam Canyon, which will affect a large area, will destroy primarily sagebrush-greasewood and juniper habitat types. The impacts of these habitat disturbances are discussed in Section 5.4.

The terrestrial and aquatic habitats outside the immediate construction and processed shale disposal areas will be protected by pollution control systems and procedures. The nature and quantities of many of the foreign substances that will enter the terrestrial and aquatic subsystems are unknown. The potential effects of many of the known substances are discussed in Section 5.4. To assure protection of the ecosystem, in addition to environmental protection procedures, a thorough and effective monitoring program must be implemented to track all potentially toxic or harmful foreign substances introduced by oil shale processing, and to assess any impacts to the ecosystem. Mitigation will be enhanced by this program which will provide an "early warning" of potential environmental harm. Descriptions and discussions of the environmental impacts, protection plans, and their anticipated effectiveness are presented in Sections 3, 4, and 5, as follows:

- Air quality and noise pollution prevention
  - Control plan, Section 4.2
  - Air quality impacts, Section 5.2
  - Impacts on major biotic groups, Section 5.4
  - Ecosystem effects, Section 5.4
- Water pollution prevention
  - Wastewater management plan, Section 3.15
  - Pollution control plan, Section 4.4
  - Drainage and erosion control, Section 4.5

- Oil and hazardous materials spill contingency plan, Section 4.11

- Impacts on major biotic groups, Section 5.4

- Ecosystem effects, Section 5.4

4.7.2 RESTORATION OF UNAVOIDABLY DESTROYED OR DAMAGED HABITAT

As presently foreseen, loss of or damage to habitat will occur in three primary locations, as shown in Figure 4.7-1:

- The process area
- Transportation corridors
- Southam Canyon

The rehabilitation and revegetation plan for disturbed areas in the first two localities is discussed in Section 4.6. This program, a continuation of the revegetation program for disturbed baseline study sites, will be applied at any time through the life of the project where native soils are to be revegetated.

The processed shale revegetation plan is also discussed in Section 4.6. This plan summarizes an ongoing research program to study and optimize the variables in the water harvesting concept. The objective of the surface rehabilitation and revegetation plan is to establish vegetation that will eventually be capable of perpetuating itself in normal conditions and of supporting wildlife of the same numbers and kinds present before the disturbance occurred.

4.7.3 ALTERNATIVE HABITAT

Alternative habitat will be made available to mobile displaced species from the disturbed areas by habitat enhancement. By effectively raising the present productivity of the selected alternative habitat, it is

anticipated that wildlife species displaced by disturbance and construction can be accommodated in selected remote areas, and will increase in population levels in those areas. Populations in these areas will probably be the source of individuals recolonizing the disturbed areas.

To enhance the alternative habitats, three steps are proposed:

- Modify present grazing practices, where possible, to increase plant biomass available for wildlife
- Improve range conditions by interseeding selected areas of low plant density with native plant species suitable for wildlife
- Create small water holding ponds to increase the carrying capacity of the habitats

These enhancement techniques would be implemented on tracts and on appropriate adjacent areas in cooperation with the concerned federal and state agencies.

One of the most effective and practical means of habitat enhancement within this cold desert ecosystem is modifying grazing practices to increase the amount of plant material available to wildlife. Approximately 6,900 sheep graze on Tracts Ua and Ub from December to April. In addition, approximately 14,000 sheep "trail" through the lease area twice each year along Utah 45, the main county road on Tract Ub, and along Southam Canyon Road on Tract Ua. Research in range management demonstrates that moderate grazing is beneficial in stimulating new shoot growth and in encouraging and maintaining a mixed grass/shrub community that offers a greater variety of forage and cover. This more diverse community benefits both native wildlife and domestic livestock (Ref. 4-18). Other studies suggest that adjusting the seasonal pattern of grazing may have similar beneficial effects. Laycock reports that heavy late-fall grazing by sheep following deferment of spring grazing improves deteriorated range condition (Ref. 4-19). The result is the reduction of sagebrush and the encouragement of grasses and forbs. Heavy spring grazing tended to produce the opposite effect and should be reduced appropriately.

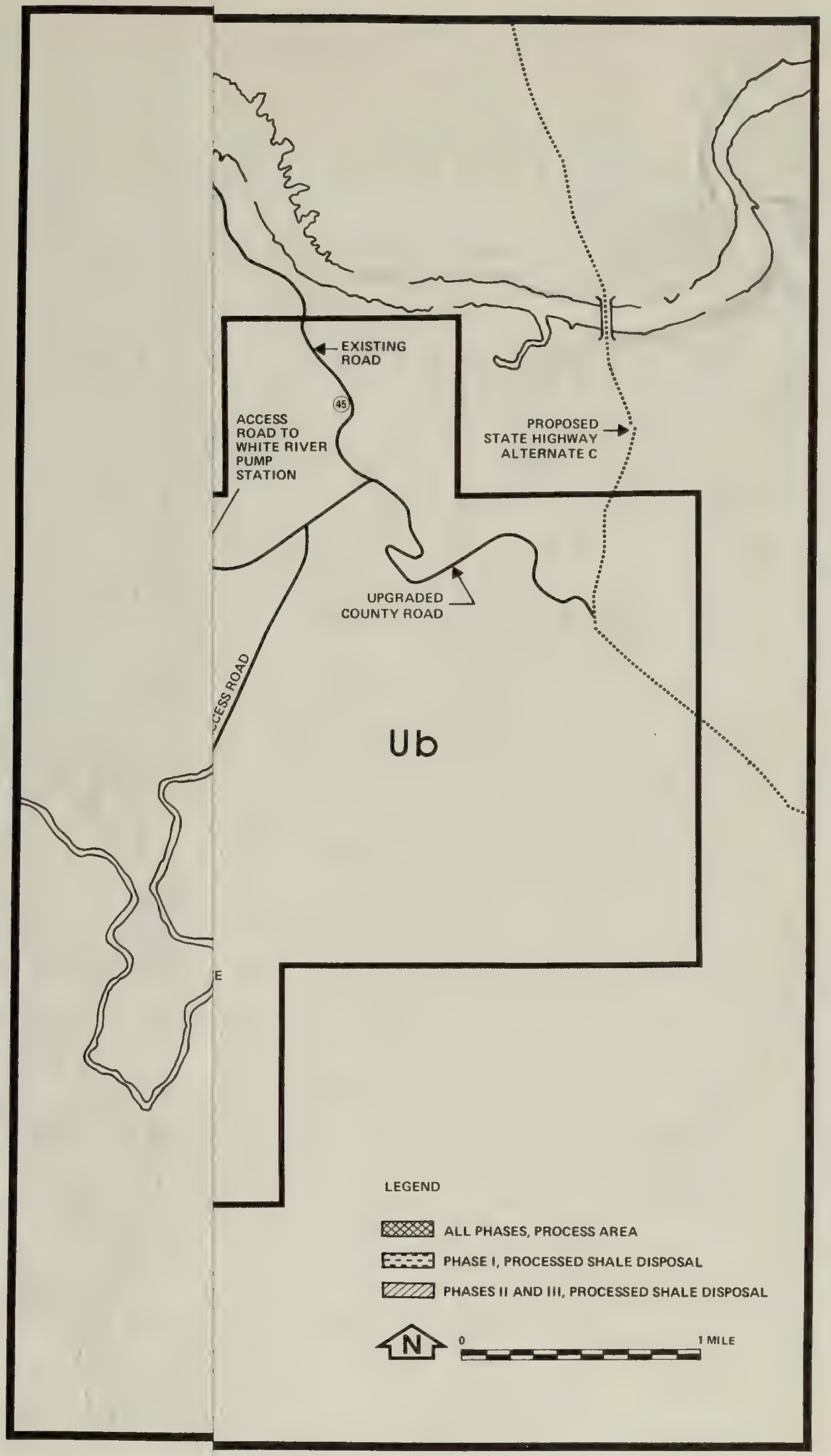


Figure 4.7-1 LOCATION OF DISTURBED AREAS

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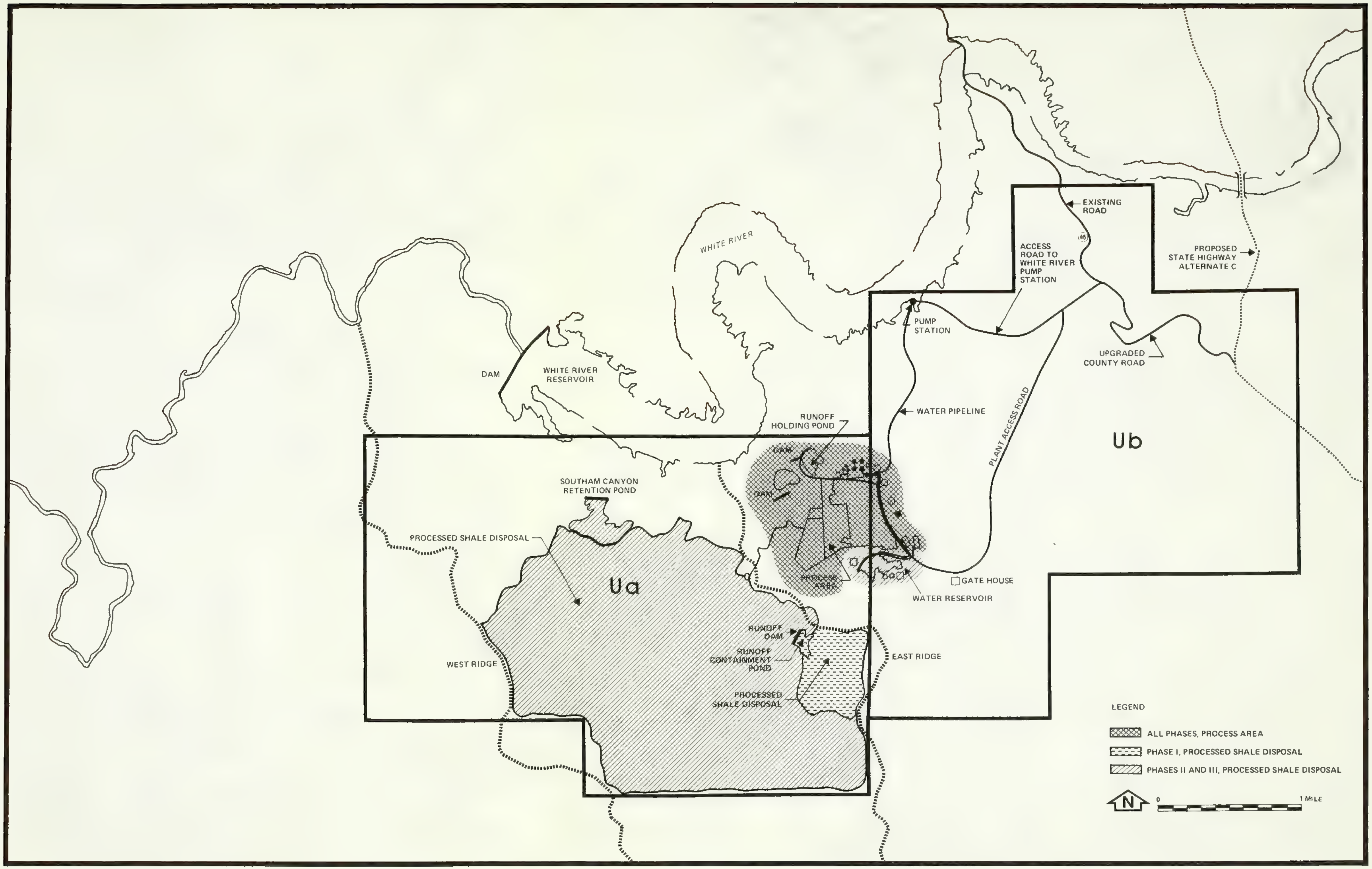

Figure 4.7-1 LOCATION OF DISTURBED AREAS

Sheep could be grazed for a shorter period of time and at lower numbers. Other range areas in the general region could be used more to compensate for the temporary loss of grazing during oil shale development. It is evident from these and other range studies that a closely managed schedule of grazing can enhance the productivity of this rangeland.

Because water is generally the limiting factor to the biota in desert systems, the construction of water impoundments to hold run-off water may be used to meet wildlife habitat capacity. Placement of water-retaining structures at appropriate locations throughout the alternative habitats could significantly increase wildlife populations. The porous nature of the soils in the area may necessitate sealing the bottom of the ponds with bentonite clay or other material to reduce seepage. The size of the ponds will depend on the topographic restrictions at each locale. The number of ponds in the various habitats will depend on the presence of appropriate locations and cost of construction.

4.7.3.1 Size and Location of the Alternative Habitat

There are about 7,400 acres of undisturbed land on Tracts Ua and Ub. Selected portions of this acreage could be used as alternative habitat for wildlife. The affected areas for each project phase and the undisturbed areas are shown in Figure 4.7-1. The rationale for selecting alternative habitat from the undisturbed land would be based on five important factors:

- Availability of vegetation of like kind
- Proximity of the alternative habitat, offering immediate access and protection to displaced animals
- Availability of ecological baseline data from the tracts that provide estimates of the present composition and functioning of the ecosystem
- Availability of biological data from the monitoring program that will allow the continual assessment of the success of the fish and wildlife management plan

- The potential for adjusting present land-use management practice to minimize the need for expensive and difficult-to-maintain alternative enhancement techniques

Four areas of potential alternative habitat are located on the tracts: Southam Canyon, areas peripheral to the process and shale disposal areas, Asphalt Wash, and most of Tract Ub. The areas are distinguished by their location and potential impact from development. In each area, the combination of habitat improvement techniques used will differ based on the projected use and impacts. Also the dominant habitat type in each area differs, which necessitates the use of different improvement techniques.

The varied topography in Southam Canyon, where the spent shale is to be deposited, provides the opportunity to establish refugia for plant and animal species. Refugia can be located in areas that are higher in elevation than the shale disposal level, such as in the south center of Section 28. Undisturbed areas can be of great benefit as habitat for less mobile animals, such as reptiles and small mammals. These areas will serve as population pools from which plant and animals colonizing the shale deposits can originate. The size and number of these refugia will depend on their location and elevation. Establishment of refugia by leaving as much natural vegetation as possible adjacent to the processed shale disposal area will produce wildlife habitat and accelerate the rehabilitation process of the disposal area.

Enhancement of areas peripheral to the process and shale disposal areas on Tract Ua can be valuable for three reasons. First, it will provide wildlife habitat near the greatest impact areas, which will minimize the displacement distance for the affected animals and provide population pools for colonization of the restored shale site. Second, Tract Ua contains most of the sagebrush-greasewood and juniper habitats on the tracts, and these will be the most impacted habitats. Any augmentation of the capacity to sustain wildlife on the undisturbed portions of these habitats will benefit wildlife. Third, enhancement of the sagebrush-greasewood habitat in the valley

bottoms between the White River and the affected areas (shale fill and process areas) will increase the capability of these areas to act as biotic buffer zones. Healthy vegetation can filter many undesirable chemicals from the surface and groundwater and the air, thus helping to protect the river system.

In the habitats peripheral to the process and fill areas, there will be a need to minimize grazing in order to encourage the accumulation of plant biomass and reduce soil disturbance. Areas disturbed by construction of retention dams, pipelines, etc. should be replanted immediately according to recommended procedures following the completion of construction. Human activities in the buffer zone should be minimized.

Asphalt Wash has the potential for providing excellent alternative habitat especially for the deer herds. Although much of the wash lies outside the tracts, the quality of the habitat in the wash may make it worthwhile for habitat enhancement. Existing wells in the wash could be managed to improve the habitat. In some areas presently receiving water from wells, young cottonwoods are already established. Ditching could expand the area receiving water and create a larger riparian area. As the riparian habitat is used by the greatest number of animal species, any increase in its area will help to meet displaced wildlife population needs. Grazing modification may be necessary at some time in the future.

The most extensive area of undisturbed habitat is on Tract Ub. The predominant habitat type is shadscale. Habitat improvement in this area may be achieved by modifying grazing practices.

4.7.3.2 Grazing Allotments

To offset the loss of grazing land on the tracts, range improvement in off-tract grazing allotments should be implemented by the appropriate federal agencies. This will benefit the ranchers as well as the wildlife. Also it may relieve grazing pressure from the on-tract reclamation areas.

4.7.3.3 Raptors

To minimize the loss of raptors due to power lines, structures will be constructed to prevent raptor electrocutions (Refs. 4-20 and 4-21).

4.7.4 HUMAN ACTIVITIES

The most serious threat, next to the fluctuations of nature, to a successful mitigation program on the tracts is uncontrolled human activities. Recreational use of the tracts will be strictly controlled. Visitors will be alerted to areas where potentially hazardous conditions exist. Hunting, fishing, and trapping may be allowed on the tracts only for game management purposes. As this is a prototype project, it will undoubtedly attract visitors. Tour guides, as necessary, and signs will be available to direct visitors around the site and thus encourage limited touring of adjacent areas.

Under the most probable plan, no living facilities will be located on the tracts. Human activities not directly related to oil shale mining and processing will therefore be reduced.

4.7.5 WHITE RIVER DAM

Off-tract disturbances such as the probable construction of the White River Dam and other facilities will contribute to the displacement of wildlife populations. To survive the flooding of the riparian habitat, resident animals will be forced to move up or down the river canyon, or out onto the higher rangeland. The few species capable of surviving on the rangeland are expected to seek refuge within the planned alternative habitat. It is also apparent that a totally new lake environment will be created, parts of which will extend onto the tracts. While identification and mitigation of environmental impacts associated with the White River Dam is a State of Utah responsibility, the White River Shale Project will cooperate with the appropriate state and federal agencies to develop a coordinated, compatible plan for the development and protection of fishery and wildlife habitats.

During commercial operation, when water is expected to be supplied from the White River Dam, intake structures will be designed for low intake velocity and fitted with suitable screens to prevent entrainment of fish.

Prior to project development, provision will be made for the on-tract installation of fences when and where necessary to direct big game around or away from construction and operation areas.

4.7.6 RELATION BETWEEN THE MITIGATION AND MONITORING PLANS

The biota monitoring program has been designed with the need to evaluate the success of the mitigation plan in mind. The fish and wildlife management plan incorporates the flexibility required to introduce further mitigation procedures as indicated by continued biotic monitoring of terrestrial and aquatic systems. The monitoring program is discussed in Section 6.6, and in Section 2.

4.8 PROTECTION OF HISTORIC, PREHISTORIC, AND PALEONTOLOGICAL RESOURCES

The historic, prehistoric, and paleontologic resources located on Tracts Ua and Ub and their 1-mile buffer zone will either be avoided and protected, or excavated. Avoidance of physical disturbance to archeological sites is preferable, but when that is impossible, sites affected by construction or operation of the White River Shale Project will be excavated to salvage material of interest. Some sites will require test excavations to determine if they are of any significance.

4.8.1 RESOURCE INVENTORY

There are no historic sites of any significance on the leased tracts. Table 4.8-1 describes each prehistoric site on tract as to contents, condition, and land ownership and lists the treatment recommended by WRSP. Paleontological resources are described in Section 5.6.

The primary historic site close to the leased tracts is the Ignatio Stage Stop located immediately south of the White River approximately 1 mile north of Tract Ub. Constructed in 1905, it was the first stop along the Uintah Railway toll road from Watson to Vernal, Utah. It has been nominated for inclusion on the National Register of Historic Sites.

4.8.2 PROTECTION PROGRAM

The mitigation program proposed for the on-tract prehistoric and paleontological sites is described in the following paragraphs. WRSP will comply with all federal, state, and local regulations pertaining to the protection of the sites described.

4.8.2.1 Prehistoric Resources

Table 4.8-1 lists the treatments recommended by WRSP for each archeological site. All off-tract sites will be avoided. On-tract sites 372, 407, and 409 will be directly affected by Phase II construction. Site 372 is surface

Table 4.8-1

PREHISTORIC RESOURCE INVENTORY

Site	Condition	Description	Land Ownership	WRSP Recommendation
ON-TRACT SITES				
42 Un 372	Undisturbed	Open site: surface scatter of lithic chipping debris; 100 m diameter	BLM	Salvage significant materials
42 Un 373	Possible surface collections made previously	Open site: chipped stone and fire-cracked river cobbles; 100 ft x 100 ft	BLM	Avoid
42 Un 324	Undisturbed	Rock shelter: lithic chips, bone, charcoal; 130 ft x 12 ft	BLM	No further work
42 Un 408	Some potholes	Open site: single flake ca. 10-15 m length	BLM	No further work
42 Un 409	Probable surface collections made previously; some erosion	Rock shelter: 2 fire stains, possible depth of deposit; 5 m x 5 m	BLM	Salvage significant materials
42 Un 407	Potholes	Rock shelter: charcoal and chipping debris exposed by potholes; 150 ft x 10 ft	BLM	Salvage significant materials
42 Un 406	Eroded	Open site: bifaces, hammer-stone, historic debitage; 100 m	BLM	No further work
OFF-TRACT SITES				
42 Un 118	Extensively van-dalized but some undisturbed deposits remaining	Rock shelter: charcoal lenses and burned soil, corn cobs, chipping debris, charred animal bones, possible 2 m depth; 50 m x 15 m	State	Avoid
42 Un 355	Undisturbed	Rockshelter: surface scatter of fine chips, one notched point; 8 ft x 60 ft	BLM	Avoid
42 Un 356	Eroded	Open site: surface scatter of chipping debris; 25 m diameter	State	Avoid
42 Un 357	Eroded	Open site: chipping debris and single projected point; 5 m diameter	State	Avoid
42 Un 358	Eroded	Open site: single projectile point	State	Avoid
42 Un 365	No apparent potholes; shelter has been littered with his-toric debris	Rock shelter: masonry granary, one projectile point, burned bone, charcoal	State	Avoid
42 Un 366	Extensively potholed	Rock shelter: pictographs, flakes, and chipping debris	State	Avoid
42 Un 367	Potholed; one 3-ft strip of deposit re-mains undisturbed; 10 ft long	Rock shelter: flakes and chipping debris	State	Avoid

Table 4.8-1 (Continued)

Site	Condition	Description	Land Ownership	WRSP Recommendation
42 Un 368	Undisturbed	Open site: chipping debris, one blade; 200 ft x 100 ft	BLM	Avoid
42 Un 369	Picked over but no potholes	Open site: chipping debris, fire-cracked cobbles; 300 ft x 200 ft	BLM	Avoid
42 Un 370	Undisturbed	Open site: chipping debris, fire-cracked cobbles; 300 ft x 100 ft	BLM	Avoid
42 Un 371	Undisturbed	Open site: fire-blackened cobbles, etched slate petroglyph	BLM	Avoid
42 Un 374	Surface picked over; no potholes	Open site: chipped stone, fire-cracked and blackened cobbles; 100 ft x 100 ft	BLM	Avoid
42 Un 375	No obvious potholes	Open site: debris and fire-cracked cobbles; 100 ft x 150 ft	BLM	Avoid
42 Un 376	Undisturbed	Open site: chipping debris, projectile points; 20 ft x 20 ft	Private	Avoid
42 Un 377 (Thompson site)	Almost totally vandalized	Open site: considerable depth with charcoal, chipping debris, and fire-blackened cobbles	BLM	Avoid
42 Un 378	No potholes but probably picked over	Open site: lithic debris; 200 ft x 200 ft	BLM	Avoid
42 Un 379	Eroded	Open site: chipping debris; and core fragments	BLM	Avoid
42 Un 380	Eroded	Open site: one projectile point	BLM	Avoid
42 Un 381	Potholes	Rock shelter: chipping debris	BLM	Avoid
42 Un 401	Some potting but mostly undisturbed	Open site: lithic debris, pottery, gray stone	State	Avoid
42 Un 402	Some potholes but good general condition	Rock shelter: flakes, scrapes, bifaces, and choppers	BLM	Avoid
42 Un 403	Good	Pictograph	BLM	Avoid
42 Un 404	Eroded	Rock shelter: possible projectile point or knife	BLM	Avoid
42 Un 405	Probable surface collections	Open site: chipping debris, sandstone slabs wall, three shallow pits; 100 m x 200 m	BLM	Avoid

scatter only, and test excavations of it are not recommended. Conclusive collection of surface finds, location recording, and site analysis has already been performed, and no further mitigation is recommended. The same applies to on-tract Sites 406, 408, and 324, which may undergo secondary impacts.

Construction activities may disclose new archeological data not evident from surface reconnaisance. A qualified state-approved archeologist at the site will ensure that all such data are recorded, salvaged, and appropriately analyzed. All on-tract archeological sites will be noted, and personnel will be instructed to avoid all unnecessary disturbance to them.

The employee indoctrination program will advise all personnel of federal and state laws prohibiting unauthorized removal or destruction of archeological resources both on and off tract. The project's quality control program will ensure that there is no unnecessary disturbance to sites on project lands by employees.

4.8.2.2 Paleontological Resources

Before construction begins, samples will be taken from the most significant sites containing fossils for preservation, examination, and analysis. If fossils are encountered inadvertently during construction or operation of the White River Shale Project, a qualified paleontologist will be consulted to evaluate and salvage significant specimens.

Exposed significant fossils on-tract will be collected, and the remainder will be preserved and protected through an indoctrination program.

All employees on the White River Shale Project will be instructed not to remove or disturb any fossils either on or off tract and will be advised of federal and state laws prohibiting such unauthorized activity. The project's quality control program will enforce this directive.

4.9 AESTHETIC VALUE CONSIDERATIONS

The design criteria adopted in project planning are primarily concerned with technical feasibility, as are the revegetation and recontouring programs that deal with such technical problems as soil stabilization and erosion control. However, aesthetic considerations must also be satisfied in these areas. The following issues are addressed to mitigate potential adverse aesthetic impacts to the project area:

- Natural Contours. To the greatest extent possible, the natural contours of the ridgetop-basin landscape unit will be utilized in the location of project facilities to reduce adverse visual impacts. All facilities including the tankage farm, shale storage tank, and retort facilities will be located in areas where the landscape offers a natural topographic screening, allowing for modifications of the terrain without excessive loss of visual character.

- Minimal Disturbed Land Area. Disturbed land area will be kept to a minimum. Only those areas required for mining, storage, processing, and disposal operations or those areas under revegetation will be disturbed. The cleared portions of the process area, where ridges will be leveled, will be kept at a minimum. Employee travel outside the construction site or away from roads will be discouraged.

- Revegetated Processed Shale Pile. The finished processed shale disposal surface will be contoured by creating shallow basins and hills resembling the natural terrain. The processed shale site is Southam Canyon; its visibility will be confined to the nearby area. The surface of the pile will be revegetated, as described in Section 4.6. It is anticipated that the surface area will eventually be covered by native flora at a density similar to adjacent areas.

- Visibility of Plant Facilities. The retort facilities and other plant facilities will be located within natural slopes and valley areas where, with the exception of stacks and headframes, they should not be visible from the White River.

- Color of Plant Facilities. All facilities will be painted unobtrusive, natural colors consistent with the surrounding landscape, such as pastels and muted shades of brown, green, red or grey to blend with the desert-redrock canyon landscape. Only warning signs will be painted bright colors. Other signs will be rustic in design and in conformance with BLM sign standards.

- Restricted Transportation. All transportation activities will be restricted to established corridors to prevent unnecessary additional disturbances to the landscape. The existing access road will be modified and will serve as a primary travel route. The new access road will conform to existing landforms as much as practicable. Revegetation of the pipeline corridors will reestablish the natural terrain.

- Utility lines will be constructed of wooden poles and nonreflective wire and will be located where feasible to minimize visibility and sky-lining.

4.10 FIRE PREVENTION AND CONTROL

The fire prevention and control plan is described in Section 3.13.5.

4.11 OIL AND HAZARDOUS MATERIALS SPILL CONTINGENCY PLAN

This section presents the general elements of an oil and hazardous materials spill contingency plan. The site-specific spill contingency operating procedure will be developed and implemented prior to startup of the facilities. The entire facility will be engineered and constructed to minimize the likelihood of emergency situations.

For the purposes of this discussion, spills fall into two categories:

- Normal Extraction and Tank Farm Area Spills. Those that occur as an unavoidable result of normal oil extraction and tank farm operations, which lend themselves to easy control and cleanup through normal operation and maintenance practices.
- Transportation-Related Spills. Those that occur outside of the process and tank farm areas, whose detection, confinement, and cleanup require designation of men and materials to prevent pollution of land and waterways in areas not dedicated to and designed for oil processing.

4.11.1 NORMAL EXTRACTION AND TANK FARM AREA SPILLS

4.11.1.1 Prevention Procedures

All operating systems will be fully tested for mechanical integrity prior to initial startup. All pressurized systems will be tested at or above maximum operating pressures depending on the applicable code. Equipment will be tested to determine whether it will meet required ratings, etc. Operating manuals that detail procedures for plant operations, including emergency procedures, will be used to train and assist operators.

Process control through extensive instrumentation and appropriate computerized and manual controls will prevent or minimize spills due to process upsets. Regular maintenance programs will check the integrity of operating systems, and repairs will be made wherever necessary. Pumps, exchangers, and piping will be designed with provisions for draining of liquids to the oily water system before being opened for maintenance or repair.

4.11.1.2 Detection Procedures

Process Area. Process control instrumentation will indicate leaks or malfunctions in all critical process streams. Central control room panels and local panels will give warnings of any upset condition. Vessels containing liquid hydrocarbons will have level indicators with high-level alarms. Waste streams and cooling water streams will be continually monitored for product or equipment malfunctions.

Tankage. Level sensor alarms will warn of improper operation and imminent spills or overflows. Regular and frequent visual checks will be made of tankage areas, and repairs will be made as necessary.

4.11.1.3 Confinement

Process Area. In general, all process areas subject to spills will be paved with suitable impervious material and shaped to prevent spills from spreading over a large area. The amount of stored hazardous materials in a process area will be limited. Concentrated acids and caustics will be either curbed or placed so that any spills or leaks are confined to the immediate storage area. Spent or contaminated acids or caustics will be collected in special drain systems and recovered for reuse or neutralized before discharge to the sewer system.

Liquid overflows will be connected to the oily water sewers or to recovery or neutralization systems. Gases will be gathered in the relief and blowdown system, which will contain liquid separation systems for recovery of liquids.

Tankage. Details of confinement dikes and dams are given in Subsection 4.4.3.3. The holding basin will be sufficient to contain a volume in excess of that equal to the combined storage volume of the tankage in use during Phase I operations. Additional dikes will be built to provide more containment volume for Phases II and III.

4.11.1.4 Cleanup

Process Area. All areas subject to spills of hydrocarbons will normally be paved with concrete. Utility water and low-pressure steam will be provided throughout the process areas and will be used to wash down spills into the oil water sewer system and for general cleanup.

Tankage. Drainage from diked areas will be manually controlled and will normally be sealed off. This will allow recovery of stored product when substantial amounts are spilled. Minor spills will be soaked up with suitable sorbents, and the surfaces will be cleaned. If the spills are on soil and a fire hazard is created, the soil will be removed. Minor amounts of oil may be washed into the holding basin. The oil will then be skimmed and stored in the slop oil tank.

4.11.1.5 Disposal

All minor hydrocarbon spills will be washed into the oily water sewer. The hydrocarbons will be recovered in the waste treatment plant and sent to the slop oil storage. The treated wastewater will be reused for dust control and processed shale wetting. Contaminated sorbents and soil will be disposed of in conformance with RCRA Hazardous Waste Rules.

4.11.2 TRANSPORTATION-RELATED SPILLS

Accidents related to transport of oil and/or hazardous materials on roads or to transport of oil by pipeline would be the likely cause of this type of spill. The following procedures will be used if a transportation-related spill occurs. In addition, prior to installation and use of a pipeline to transport oil produced in the commercial operation phase, the Spill Contingency Plan will be revised to include specific plans to cope with pipeline spills or leaks.

4.11.2.1 Prevention Procedures

The prevention of spills of oil and hazardous materials is a primary objective of White River Shale Project. The key to prevention is the establishment of an awareness of spill potential among the White River Project and contractor personnel through personnel education.

There will be orientation sessions for all project supervisory personnel, using films and literature supplied by equipment manufacturers, the federal government, and the American Petroleum Institute. White River Shale Project management will set up and conduct training sessions and will maintain records of the sessions and of personnel thus trained. In addition, review sessions will be organized periodically to keep the training program current and to ensure that proper instructions are given to employees who may be either new to the job or transferred from other assignments where oil spill contingency training was not given.

Adequate roads, maneuvering areas and speed controls will be provided on tract to minimize spills due to collisions. Refueling of construction equipment will take place away from water course; the equipment will have nozzles with a positive shutoff to avoid spillage from over-filling. Strict fire prevention measures will be observed during refueling. Vehicle maintenance will be performed in designated areas only.

4.11.2.2 Action Procedure

A White River Shale Project or contractor employee at the scene of the operation who first learns about a spill will observe whether or not:

- Any human life or property is in danger
- The spill can be readily stopped or controlled

If human life or property is in danger, the employee will take prompt action to alleviate the danger. If the spill can be stopped or brought under control readily, the employee will do so and then notify his supervisor as soon as

possible. If there is any doubt as to whether an incident constitutes a reportable spill, the employee will initiate the action procedure.

When the cognizant supervisor has been notified that a spill has occurred, he will:

- Determine that mobilization is under way to contain the spill
- Arrange for and dispatch additional personnel, material, and equipment as needed
- Set up communications relative to the emergency
- Ensure that the spilled material is recovered and properly disposed of
- Notify the Area Oil Shale Supervisor and other appropriate federal and state agency personnel
- Gather information for the spill report
- Ensure that the spill area is properly cleaned

The following information will be gathered and confirmed by the cognizant supervisor as soon as possible.

- Date and time spill occurred or was first observed
- The original and present location of the spill
- Estimate of amount spilled and type of substance
- Environmental conditions: temperature, wind direction and speed, rain, snow
- If the spill is from a vehicle, the type, registration, owner, and operator of the vehicle
- Description of area likely to be affected, such as roadway, ditch, hillside, drainage
- Cause of spill, if determined

- Action taken to prevent recurrence of spill
- Agencies or persons notified

The senior White River Shale Project representative on tract will determine that all White River Shale Project facilities are available, as needed, for use in the spill emergency. He will be responsible for giving immediate notice of any spills or discharges of oil or other hazardous substances to the Area Oil Shale Supervisor and other federal and state officials.

Cleanup Procedure. Spills that occur on land will be cleaned up by recovering the pooled substance and removing the affected soil, if the soil is pervious, or by absorbing the substance, if the soil is impervious. Soils removed because they were contaminated with spilled matter will be disposed of according to applicable hazardous waste rules.

The likelihood that accidentally spilled oil or hazardous material will reach navigable waters is remote because the access road will pass through only one drainage on tract that has a perennial watercourse (Evacuation Creek). Reponse to a spill in this area will be aimed at confining the spilled substance before it reaches the watercourse.

In the event that it is not possible to confine the spilled substance before it reaches the watercourse, equipment and materials specifically designed and previously successfully used for recovering spilled substance will be readily available. This equipment and material, consisting of a containment boom, pumps, hoses, skimmer, small boat and motor, absorbent material and miscellaneous hand tools, will be kept in a protected pre-designed location suitably marked and available for use to authorized personnel. This equipment for spill contingencies will not be used for other purposes.

In addition to the above, trucks, graders, loaders, vacuum tanks, and other related mechanical equipment will be available for use in the containment and cleanup of any spilled substance.

Materials specifically designated for use only on spill cleanup will be stored in a well-marked location known and accessible to all personnel. Materials will be adequately marked for identification, protected from the elements, and not used for other purposes.

4.11.2.3 <u>After-Spill Procedure</u>

When a spill has been contained and cleaned up, the cognizant supervisor will make sure that all usable materials employed in the operation are cleaned and checked for serviceability. Materials specifically designated for spill containment and cleanup will be returned to the original storage area. Consumables and damaged items will be restocked to maintain minimum levels of listed spill contingency equipment.

An environmental assessment of the area affected by the spill will be conducted. A report will be sent to the Area Oil Shale Supervisor, and this report will describe:

- Area affected by the spill
- Extent of damage, if any, to the flora and fauna
- Proposed remedial measures

4.12 PREVENTION OF HAZARDS TO PUBLIC HEALTH AND SAFETY

Safety responsibilities for avoiding hazards to public health are primary considerations in the White River Shale Project. Table 4.12-1 identifies possible public hazards and the protection measures proposed.

4.12.1 ENVIRONMENTAL REGULATIONS

Section 5 of the Oil Shale Lease Environmental Stipulation requires that all necessary measures be taken to protect the health and safety of persons affected by White River Shale Project activities. All public access to hazardous areas will be controlled (Environmental Stipulations, Section 2) and, if it is necessary, will remain controlled.

Sections III-84 and 88 of the Code of Waste Disposal contain provisions requiring isolation of sanitary waste stabilization ponds. Although these requirements do not specifically apply to the impoundments planned for WRSP, Section III-91 "Industrial Waste Ponds" states that ponds receiving industrial wastewater (containing no domestic wastewater) are subject to design requirements determined by engineering analysis and other sources. On this basis, Utah Code Section III-84 "Isolation" is assumed to apply to access control of all impoundments planned for WRSP. This section stipulates that waste ponds be enclosed with a fence adequate to exclude small animals, livestock, and people, and that locked access gates must be provided. Signs that describe the nature of the facility and advise against trespassing will be posted.

4.12.2 MINE PORTALS AND SHAFTS

All mine portals and shafts outside the main plant security system will be fenced and posted to warn trespassers. When the mine is abandoned, all mine shafts will be sealed and rehabilitated.

Table 4.12-1

SUMMARY OF PUBLIC HEALTH AND SAFETY MEASURES

Type of Activity	Construction Phase of Each Activity			Operation Phase of Each Activity	
	Construction Schedule	Hazards	Protective Measures	Hazards	Protective Measures
Mine Portals and Shafts					
Phase I	Before Phase I	Blasting, material and equipment movement	Access road control with guards and signs, plus additional signs around blasting area (accepted safety practice when blasting)	Mine shafts and equipment movement in and out of mine	Entire process area, stockpile, and mine area Is fenced and/or placarded with warnings
Phase II Shafts	Before Phase II	Same as above	Same as above	Mine entrance and mine shafts, and equipment movement	Mine entrance is within fenced area. Shafts outside process area will be fenced and placarded
Phase III Mine Shafts	Before Phase III	Same as above	Same as above	Same as above	Same as above
Process Area and Tankages					
Phase I	Before Phase I	Blasting, grading, and hauling equipment, etc.	Same as above. Area to be fenced as soon as possible	Process equipment, mass material movement, flammable hydrocarbon storage, etc.	Process area and mining activities will be fenced and placarded and access road entrance controlled
Phases II and III	Before Phase I	Same as above	Same as above	Same as above	Process area, tank farm, and mine adits are fenced and placarded. Gate is guarded and access road placarded
Access Road and Other Passages					
Access Road	Before Phase I	Same as above	Flagman and placarding as required.	Heavy truck and equipment traffic during Phases I, II, and III	Frequent speed limit signs and caution signs, and restriction of access to mine and process areas
Other Passages Through or into the Tracts	Before Phases I, II, and III	No improvements planned. Road crossing in Southam Canyon may be hazardous during processed shale disposal operations	Placarding all roads entering tract.	Occasional traffic of heavy trucks and other equipment	Same as construction phase

Table 4.12-1 (Continued)

Type of Activity	Construction Phase of Each Activity			Operation Phase of Each Activity	
	Construction Schedule	Hazards	Protective Measures	Hazards	Protective Measures
Processed Shale Disposal					
Phase I	Before Phase I	Conveyors, trucks, and construction equipment movement	No public access. Placarding restricting access to fill area and conveyor truck routes	Conveyor, trucks, and equipment movement at fill site	No public road approaches this area. Placarding along routes and fill area restricting access
Phases I, II and III	Before Phase II	Construction grading, and equipment movement for conveyor pathway	Same as above	Conveyor operations, truck, stacker, and equipment movement in Southam Canyon	Reroute or close road crossing Southam Canyon as above. Restrict and placard all other possible entries to canyon
Impoundments					
Freshwater Reservoir	Before Phase II	Construction equipment and material movement for dam	Placarding around site	No water quality hazard. Trespassing on dam may be hazardous	Placarding to discourage trespassing and swimming. Fencing of dam to prohibit trespassing
Impoundments South of Processed Shale Disposal Fill	During Phase III	Same as for processed shale disposal	Provisions same as for processed shale disposal	Water may be contaminated by contact with processed shale	Placarding to discourage trespassing and swimming
Phase I Catchment	Before Phase I	Same as freshwater reservoir	Same as freshwater reservoir	Water contaminated by contact with processed shale. Trespassing on dam dangerous	Pool and dam placarded
Southam Canyon Retention Dam	Before Phase II	Same as above	Same as above	Same as above	Same as above
Wastewater Holding and Storm Runoff Basin	Before Phase I	Same as above	Same as above	Contaminated water contact and trespassing on dams hazardous	Dam and pool contained in process area fenced. No other procedures required
Product and Freshwater Pipelines					
Freshwater Pipeline	Before Phase I	Heavy equipment movement and some blasting	No new placarding required except over buried pipe warning against excavation	No hazard during operations since buried. Pumping stations may be hazardous to trespassers	Pumping house placarded and fenced. Signs over pipeline maintained
Product Pipeline	Phase II	Same as above	Same as above	Slight hazard during operations if pipe ruptures	Placards over pipeline maintained

4.12.3 PROCESS AREA AND TANK FARM

In accordance with Utah Code specifications, fences and placards to warn trespassers will be erected around the process areas for each phase of the WRSP as soon as construction begins. Entrances to the plant will be controlled by guards located on all major access roads.

During abandonment, all process equipment will be dismantled and removed, all cavities filled over, and sharp protrusions such as reinforcing bar eliminated. Concrete pads and subsurface structures will be left in place, and should not present any danger to the public.

4.12.4 PLANT ACCESS ROADS

Speed limits and caution signs will be posted on the plant access roads, and warning signs will be erected at the tract boundaries and entrance trails. The dirt road that passes from east to west across Southam Canyon will be closed to public traffic. Alternate access road locations will be investigated.

4.12.5 PROCESSED SHALE DISPOSAL

Processed shale conveyors, trucks, and other heavy equipment may pose hazards to the general public. To minimize such hazards, all public access to the plant and its ancillary facilities will be prohibited for the duration of the project.

4.12.6 WATER AND WASTEWATER IMPOUNDMENTS

The freshwater reservoir will store uncontaminated water. Catchments downstream from the processed shale deposit will contain contaminated water during the life of the project, but this water will be used in various activities. The wastewater holding basin may also contain contaminated wastewater from the process area. Impoundments filled with contaminated water not already located within the larger enclosures will be individually fenced and placarded with cautionary warnings.

After abandonment, all impoundments will be emptied or left as an evaporation pond, with the exception of Southam Canyon retention dam, which will remain operational. The retention dam will remain fenced and placarded. Dam structures for all other impounds will remain enclosed and placarded. For further discussion, refer to Section 5.8.

4.12.7 PRODUCT AND FRESHWATER PIPELINES

No public health hazards are expected to develop from either the product or freshwater pipelines since they will be underground. Signs will be posted along each route warning against excavation.

Freshwater pumping facilities constructed near the bank of the White River during Phase I will be fenced and posted.

4.12.8 CONSTRUCTION ACTIVITIES

Construction activities such as earth moving, blasting, sinking shafts, grading, installation of equipment, and other related work will necessitate precautionary methods which, among other things, will prohibit public access into the construction area.

4.12.9 CARCINOGENS

The White River Shale project is aware of the concern that shale oil production may involve certain potential carcinogenic hazards. Extensive and continuing studies have not revealed an abnormal incidence of human cancer associated with oil shale mining and processing.

Based on completed studies and information obtained from ongoing programs, the following facts relating to oil shale products, by-products, and raw oil shale are evident:

- Chemical analyses indicate that the trace element content of oil shale approximates earth crustal averages and contains no unusual concentrations of known carcinogenic compounds.

- The polycyclic aromatic hydrocarbon (PAH) content of oil shale solids (both raw and processed) is similar to or less than the amounts found in certain soils and sediments.

- Processed oil shale is non-carcinogenic to both animal skin and lungs under lifetime exposures.

- The acute and chronic toxicities of solid oil shale materials are very low.

- Carcinogenicity of raw shale oil is at least equivalent to similar conventional petroleum streams.

- Upgrading of the raw shale oil through hydrotreating substantially reduces its carcinogenic potential.

The White River Shale Project will continue to monitor the results of studies investigating carcinogenicity of oil shale and its derivatives, and will be responsive to those results. Current information, however, indicates that commercial oil shale mining, processing, and retorting operations that incorporate current accepted health and safety practices will not subject employees or the general public to unacceptable carcinogenic risks. The White River Shale Project will provide all necessary safeguards to protect the health of its employees and the public.

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Section 5

ENVIRONMENTAL EFFECTS OF THE PROPOSED ACTION AFTER MITIGATION

5.1 INTRODUCTION

Section 5 discusses the potential project impacts on each of the six environmental resources — water, air, biological, soils and geology, historic and scientific, and aesthetic — and briefly touches on the environmental effects of decommissioning and abandonment. The analyses are predicated on the implementation and normal operation of all pollution control systems and environmental protection plans proposed in Sections 3 and 4 of the DDP to conform with the applicable federal, state, and local statutes and the lease requirements. The analyses reflect current estimates of the most probable case; however, in several instances, worst case conditions have been assumed in order to demonstrate that the predicted impacts can be satisfactorily mitigated.

5.2 EFFECTS ON AIR RESOURCES

5.2.1 INTRODUCTION

The air quality impacts of operating Phase I and Phase III of the project were assessed through diffusion modeling. Phase II was not modeled, since emissions and impacts are expected to be roughly one-half of Phase III.

Table 5.2-1 presents the total emissions for the major criteria pollutants in both pounds per day and tons per year for operation of Phases I and III. These emissions are discussed in detail in Section 4. Applicable National Ambient Air Quality Standards (NAAQS) and EPA incremental standards for Prevention of Significant Deterioration (PSD) are also discussed in Section 4. The intent of air quality modeling for the DDP was to show that Phase I operation could comply with those standards, and to predict the impacts of Phase III operation.

Of the five criteria pollutants for which emissions are given in Section 4, the ones with potentially the greatest impact during both phases are TSP, SO_2, and NO_x. Although CO and HC emissions are of the same order of magnitude as SO_2 emissions, the standards for CO and HC are at least an order of magnitude higher than those for SO_2. SO_2 impacts are minute, so CO and HC impacts would be totally insignificant. Therefore, in the following analysis, only the impacts of TSP, SO_2, and NO_x are discussed.

Two dispersion models were used to analyze the air quality impacts. The PTMAX model was used to derive worst-case meteorological conditions for short-term analyses. All projected concentrations for annual averages of TSP, SO_2, and NO_x, 24-hour averages of TSP and SO_2, and 3-hour averages of SO_2 were made via a modified version of the VALLEY model.

In addition to quantifying impacts on the surrounding areas near lease tracts Ua and Ub, the impacts of TSP and SO_2 on the nearest Federally

Table 5.2-1

ESTIMATED EMISSIONS FROM PROJECT OPERATION
lb/day
(ton/year) [a]

Pollutant	Phase I		Phase III	
	Without Control[b]	With Control	Without Control[b]	With Control
TSP	34,802 (6,352)	1,558 (284)	883,422 (161,221)	10,484 (1,913)
SO_2	409 (75)	409 (75)	3,448 (629)	3,448 (629)
NO_x	5,720 (1,044)	5,720 (1,044)	46,469 (8,481)	46,469 (8,481)
HC	217 (40)	217 (40)	1,608 (293)	1,608 (293)
CO	1,106 (202)	1,106 (202)	7,388 (1,348)	7,388 (1,348)

(a) Tons per year calculated assuming plant operation 365 days per year, 24 hours per day.

(b) Without control, SO_2 emissions will be reduced 99 percent by treating the gas prior to combustion. Without control, combustion particulate will be reduced by 50 percent by treating and cleaning the fuel. Without control, HC, CO, and NO_x emissions will be reduced by 90 percent through the use of treated gas, low NO_x burners, and combustion control. Emissions without control shown in the table include such allowances.

Mandated Class I area (Flat Tops, about 82 miles east) and the nearest proposed Class I area (Dinosaur National Monument, about 35 miles north) were also calculated. Figure 5.2-1 shows the location of Tracts Ua and Ub in relation to these areas.

5.2.2 DESCRIPTION OF THE MODELING APPROACH

5.2.2.1 The EPA "PTMAX" Model

PTMAX was used to obtain information about the dependence of maximum ground-level concentration on meteorology for short-term averages on a source-by-source basis. PTMAX is part of EPA's UNAMAP series of atmospheric dispersion models and is discussed in detail in Reference 5-1.

PTMAX is a steady-state Gaussian plume model for diffusion in flat terrain. It computes the maximum ground-level concentration for a point source and the distance from the source at which it occurs as a function of wind speed and atmospheric stability class. The output also includes the plume centerline elevation at the maximum ground-level impact points.

5.2.2.2 The EPA "VALLEY" Model

VALLEY was used for screening-level estimation of the impacts of Phase I and Phase III emissions in both the short and long term. This model is described to some extent in Reference 5-2.

VALLEY is a steady-state Gaussian dispersion model for multiple point and area sources, and it includes an algorithm for simulating the effects of complex terrain on ground-level concentrations. In estimating annual-average concentrations, VALLEY uses a statistical routine requiring a joint frequency distribution of atmospheric stability, wind speed, and wind direction. VALLEY also simulates dispersion for 24-hour averages by specifying a single stability/wind speed/wind direction meteorology, which the model then assumes persists for 6 hours out of the 24-hour scenario.

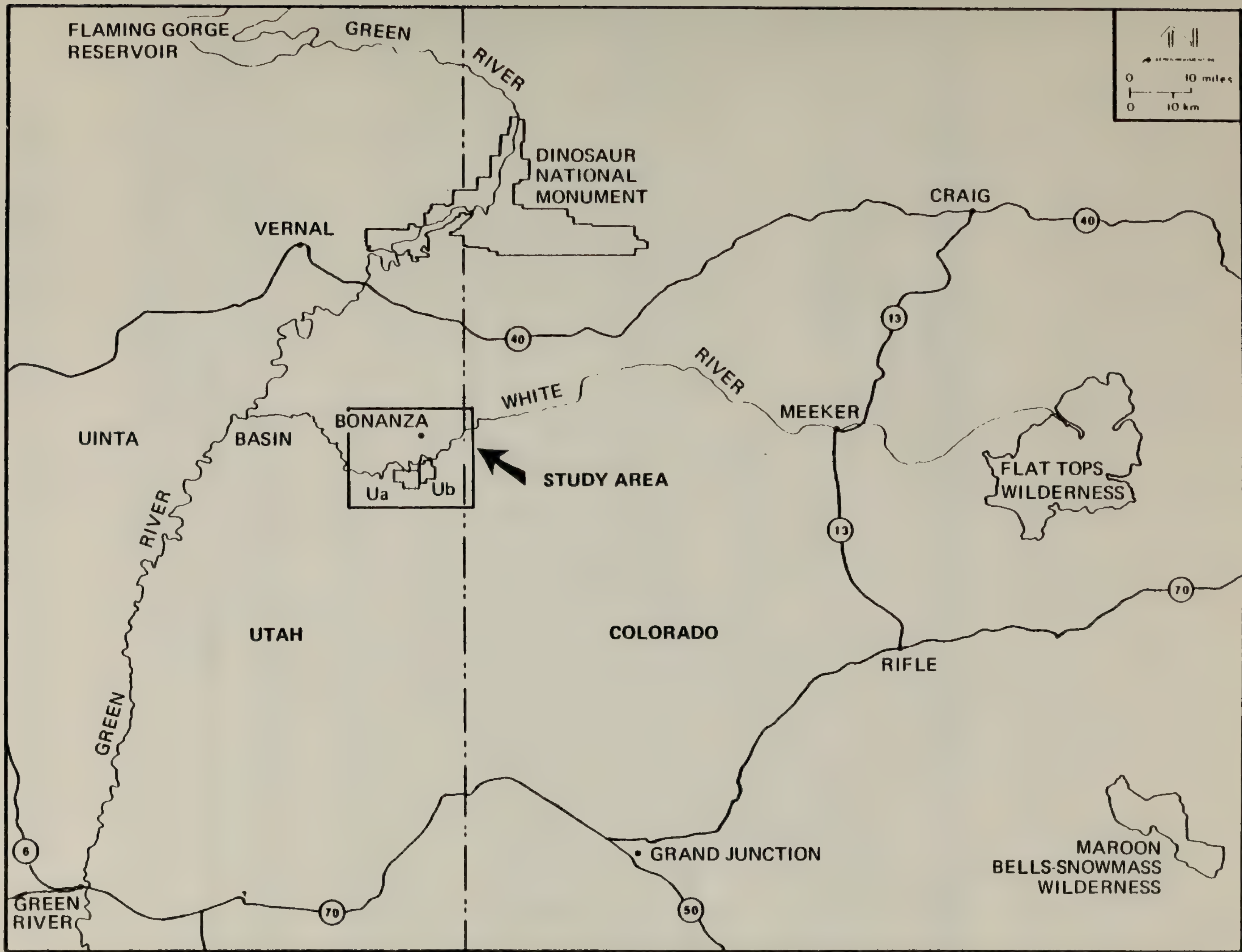


Figure 5.2-1 STUDY AREA WITH RESPECT TO EXISTING AND PROPOSED CLASS I WILDERNESS AREAS

The algorithm for simulation of effects of complex terrain is illustrated in Figure 5.2-2. For stable atmospheric conditions, the model assumes that the plume height above stack base remains constant after final plume rise. Thus as terrain rises, the plume approaches the elevated surface since the plume height above terrain decreases.

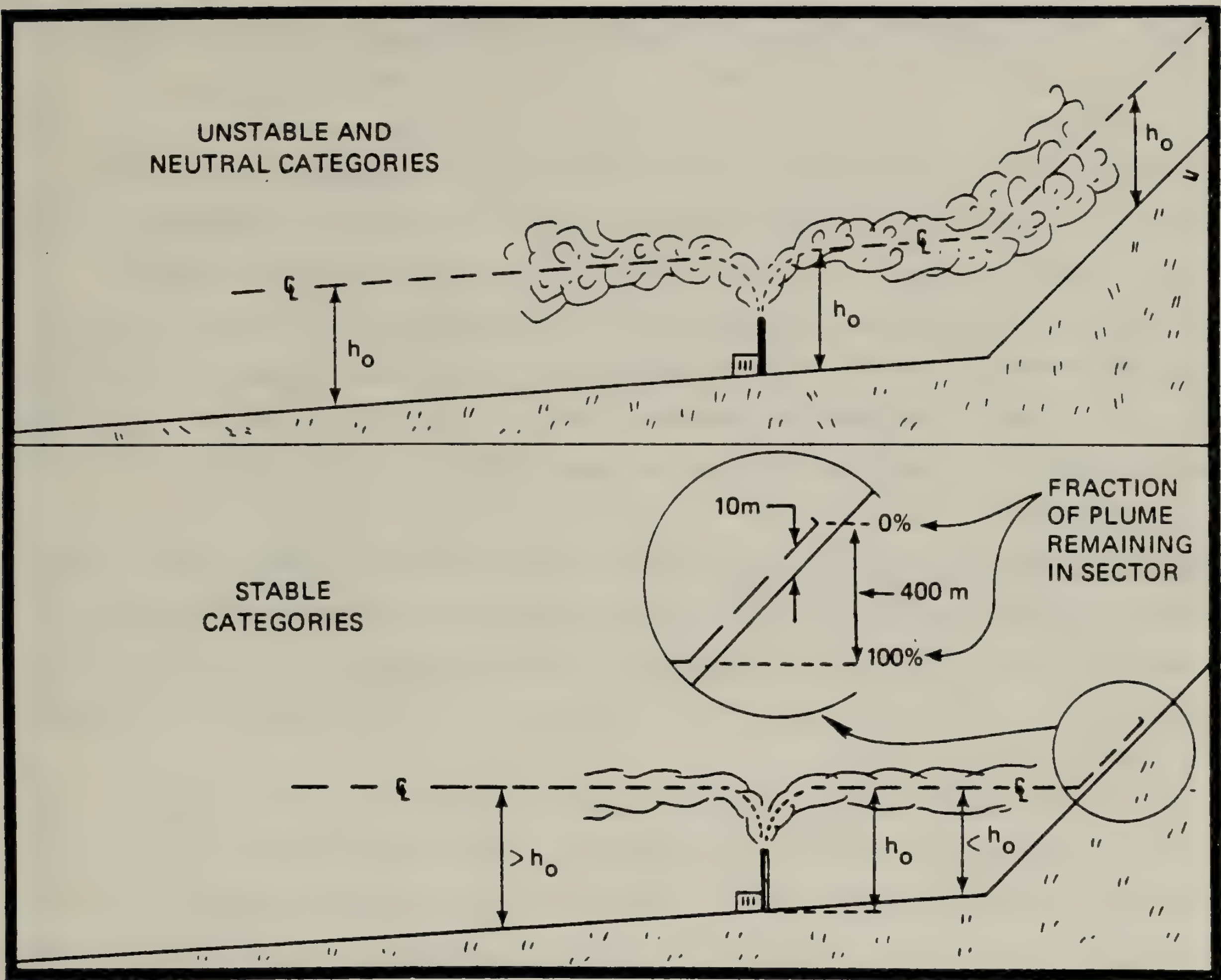
For neutral or unstable atmospheric stability conditions, the plume is assumed to follow the terrain at constant height above the ground after final plume rise. This is, in effect, a flat-plane simulation and may result in slight underestimation of concentrations since plumes may actually approach terrain in unstable conditions.

5.2.2.3 VALLEY Modifications

The VALLEY terrain algorithm was used as the core of the model developed to measure the impacts of oil shale development on Tracts Ua and Ub. However, the EPA Office of Air Quality Planning and Standards does not recommend models incorporating complex-terrain algorithms that treat cases where terrain extends above release height, which is true for the WRSP. On the other hand, VALLEY is recommended for this application by the state of Utah's Bureau of Air Quality (UBAQ) and by the EPA Region VIII permits section. To obtain a more accurate assessment of air contaminant emission impacts VALLEY was modified. These modifications include different diffusion algorithms and plume rise equations and are discussed below.

Refined Treatment of Dispersion Coefficients. The treatment of dispersion coefficients used for this application is identical to ones found in AeroVironments AVMSTM and AVACTA complex-terrain dispersion models. The AVMSTM model was applied and validated for an oil field application in Bakersfield, California (Ref. 5-3) and AVACTA was applied and validated for Tract Cb in Colorado (Ref. 5-4).

The dispersion algorithms used are modified versions of formulae suggested by Briggs (Ref. 5-5) for open country conditions. The Briggs formulae



NOTE: h_o is the height of the plume rise above ground for the unstable and neutral cases and above stack base for the stable cases. Plumes are shown for flows toward and away from elevated terrain.

Figure 5.2-2 PLUME HEIGHT IN COMPLEX TERRAIN (AS IN THE VALLEY MODEL)

were rewritten in terms of σ_θ (the standard deviation of the horizontal wind direction within an hour) for each stability class by Mullen et al. (Ref. 5-3). In complex terrain, dispersion calculations based on lapse-rate-determined stability categories or on the Pasquill stability categories generally underestimate the diffusion, since topographically generated mechanical turbulence is not represented. Measured values of σ_θ, however, form a continuous and directly related function of the turbulence. These modified Briggs formulae include σ_θ explicitly and were used through computation of a σ_θ-based stability distribution.

The effects of terrain roughness were explicitly incorporated into the revised Briggs formulae following derivation of empirical equations relating turbulence to topography. These were based on measurements obtained in the Air Force's LO-LOCAT program (Ref. 5-6). The terrain roughness is determined objectively by a spectrum analysis of terrain elevations — from a USGS topographic map, for example — near the area of interest. These dispersion coefficients were used throughout the analysis.

Refined Treatment of Plume Rise. Most models currently available calculate plume rise based on buoyancy flux alone, with no inclusion of the initial momentum flux. When modeling thermally ambient plumes (cold jets), these routines set the plume rise to zero independent of initial exhaust velocity and ambient wind profile.

In this analysis we incorporated cold-jet plume rise formulae based on the treatment of Briggs (Ref. 5-7). The routine calculates plume rise solely through conservation-of-momentum considerations and is used for all ambient jets. Buoyancy-flux based plume rise routines are applied for thermally elevated releases. This approach is also used in the AVACTA model, which was validated on Tract Cb for a similar application (Ref. 5-8).

5.2.3 INPUTS TO THE MODELING ANALYSIS

5.2.3.1 Meteorology

The VALLEY model requires a joint frequency distribution based on wind speed, wind direction, and stability class for long-term analyses. As discussed in Subsection 5.2.2.3, stability categories based on σ_θ are more representative of the turbulence intensities in complex terrain than are lapse-rate categories or Pasquill categories. Wind speed, direction, and σ_θ were monitored continuously at Site A6 since 1975. The data are representative of the meteorology for Tracts Ua and Ub. Thus, the joint frequency distribution of wind speed, direction, and stability required by the model was calculated from A6 data, using data from 1975 to 1979.

For short-term (i.e., 24-hour) analyses, the PTMAX model provided worst-case meteorological scenarios on a source-by-source basis. Comparing the summary impacts from all sources for each meteorological condition, it was determined from the PTMAX simulations that stable conditions (stability category F) coupled with a 2.0-meter-per-second wind speed would be the worst-case meteorology for the short term. The worst wind direction was determined by running the modified VALLEY model for all combinations of wind direction, pollutant, and operation phase, as discussed in Section 5.2.5.

VALLEY also requires input of the mean afternoon mixing height, which was determined from Ref. 5-9 to be 2,500 meters. The model assumes the mean nocturnal mixing height to be 100 meters. Mean ambient temperature and pressure of 45F and 24.84 in., respectively, were input from values obtained at Site A6 in the baseline program.

5.2.3.2 Source Characteristics and Emission Rates

Complete emission inventories and source characteristics are given in Tables 4.2-4 and 4.2-5. The locations of the sources within the process

area are shown on Figure 3.4-2. The shale disposal areas and their locations with respect to the process area and to the tract boundaries are depicted in Figure 3.4-1.

For each point source with a stack (i.e., with initial momentum flux as specified in the tables in Section 4.2) the model was supplied with the UTM coordinates of the source location, the elevation in feet above sea level of the stack base, exhaust temperature, emission rate in g/sec of each pollutant, the stack height above base, stack internal diameter, and volumetric flow rate in m^3/sec. If the exhaust temperatures were ambient, the plume rise was calculated based on momentum flux. Thermal exhausts — and the single flare from Phase I — were treated as buoyant plumes with plume rise calculated as such.

Emissions from traffic exhaust during shale disposal operations, traffic-related dust entrainment, and wind erosion were modeled as groups of area sources of ambient nature with no initial momentum and no plume rise above release height. Emissions from spoils piles were modeled as releases from a height above ground elevation equivalent to the expected height at the top of the disposal pile. Traffic-related emissions during disposal were distributed evenly throughout these modeled area sources. For small ore stockpiles, a minimum height of release of 7 meters was assumed. This minimum corresponds to an approximate height at which general operations and wind erosion would disturb the dust in order to generate emissions. These assumptions are in line with UBAQ guidelines.

Annual average scenarios were run with emission rates in g/sec equivalent to the lb/day rates given in Tables 4.2-4 and 4.2-5, strengths adjusted to include a plant operating factor of 90 percent (10 percent downtime) for all stack sources and traffic-related emissions. Wind erosion emission rates were also scaled down to represent emissions occurring only on days with total precipitation less than 0.01 inch. At the WRSP site, 275 days of each year over a climatological data base were used as the number of dry days (Ref. 5-10). These two adjustments were not made for worst-case 24-hour averages.

For particulates, emissions were also adjusted to include only the fraction of the mass assumed to have a particle diameter below 30 μ. This was done because compliance with air quality standards for particulate matter is determined by high-volume samplers that, typically, have an aerodynamic cutoff of 30 μ (Ref. 5-10). The comparison of monitored data with standards thus applies to the fraction of the suspended particulate with diameters less than 30 μ. Particles larger than 30 μ also possess very large deposition velocities in the surface layer and will fall out of the plume very rapidly. The fraction under this cutoff for the various sources was calculated and is presented in Table 5.2-2.

For NO_2 emissions, a 100 percent conversion rate to this form of the NO_x emitted was assumed, an assumption which will lead to a prediction of maximum NO_2 impacts.

These characteristics and emission rates are summarized in Tables 5.2-3 and 5.2-4 for Phase I and III, respectively.

5.2.3.3 Receptor Grid Layout and Incorporation of Terrain Roughness

Two concentric radial receptor grids were used with modified VALLEY to determine the distribution of concentration in the area near Tracts Ua and Ub. A close-in grid consisted of seven receptors along each radial direction with approximately 400-meter radial increments. The coarse grid also contained seven receptors, although the radial increment was increased to approximately 1,400 meters. Several receptors based on this scheme were located in either the process area or the shale disposal area, and these receptors have been deleted from Figures 5.2-3 and 5.2-4. More receptors were deleted from the Phase III figure since the shale disposal pile is expected to fill in more area of Southam Canyon as the operation continues. Roughly 53 percent of the Phase III disposal area shown in Figure 5.2-2 will be filled in by year 15 (the year assumed in this analysis). Predicted concentrations at the receptors located within the process area or shale disposal areas are not included in the discussion of impacts. On these maps, both the fine and coarse receptor grids have been overlaid.

Table 5.2-2

PARTICULATE FRACTIONS UNDER 30 μ DIAMETER

Source Class	% of Mass Below 30 μ Diameter	Source Type Within the Classes
Mine Operations[(a)]	86	Mining, blasting
Crushing[(a)]	60	Crushing, screening, stockpiles, transfer points, moisturizers
Retorts[(a)]	68	Retorts
Shale Disposal[(a)]	74	Shale disposal pile
Combustion Products	100	Mine equipment, heater for retorts, incinerator, boiler, traffic exhaust
Traffic-Entrained Dust (Dirt Road)[(b)]	32	Shale disposal traffic fugitive emissions

(a) Source: Reference 5-11.
(b) Source: Reference 5-10.

Table 5.2-3

PHASE I SOURCE INVENTORY

Source Category	UTM Coordinates Zone 12(a)		Ground Elevation (ft above MSL)	Emission Rates (g/s)						Source Characteristics					
				Annual			Short Term			Source Height (m)	Stack Diam. (m)	Exhaust Temp. (k)	Exit Vel. (m/s)	Actual Volume Flow (m^3/s)	Area Source Width(a) (m)
	(km E)	(km N)		TSP	SO_2	NO_x	TSP	SO_2	NO_x						
Mine Vent	654.83	4421.32	5525	0.95	0.73	10.30	1.06	0.81	11.40	0.0	8.50	281	19.1	1084.0	-
Transfer Points	654.48	4421.62	5355	0.01		-	0.01	-	-	15.2	0.45	281	17.6	2.8	-
Coarse Shale Stockpile	654.35	4421.26	5425	0.13	-		0.16	-	-	7.0	-	281	-		120
Secondary Crushing	654.23	4421.62	5465	0.24	-		0.27	-	-	15.2	0.59	281	20.2	5.5	-
Fine Shale Stockpile	653.70	4421.84	5260	0.43		-	0.51	-	-	7.0	-	281	-		325
Shale Moisturizer	654.39	4421.57	5410	0.01	-	-	0.01	-	-	7.0	0.91	311	0.9	0.6	-
Indirect-Retort Heater	654.40	4421.61	5375	0.08	0.06	2.39	0.09	0.07	2.65	30.5	1.37	422	26.1	38.5	
Incinerator Flare	654.14	4421.87	5285	0.71	0.51	6.36	0.79	0.57	7.07	30.5	1.37	700	83.0	122.4	-
Boiler	654.43	4421.49	5385	0.32	0.23	2.57	0.36	0.25	2.86	30.5	0.99	450	56.8	43.7	-
Shale Disposal	653.46	4420.38	5550	1.56	0.40	5.46	1.75	0.44	6.07	60.0	-	281	-	-	725

(a) Coordinates for area sources are the coordinates of the SW corner of a square area whose side length is given as the width.

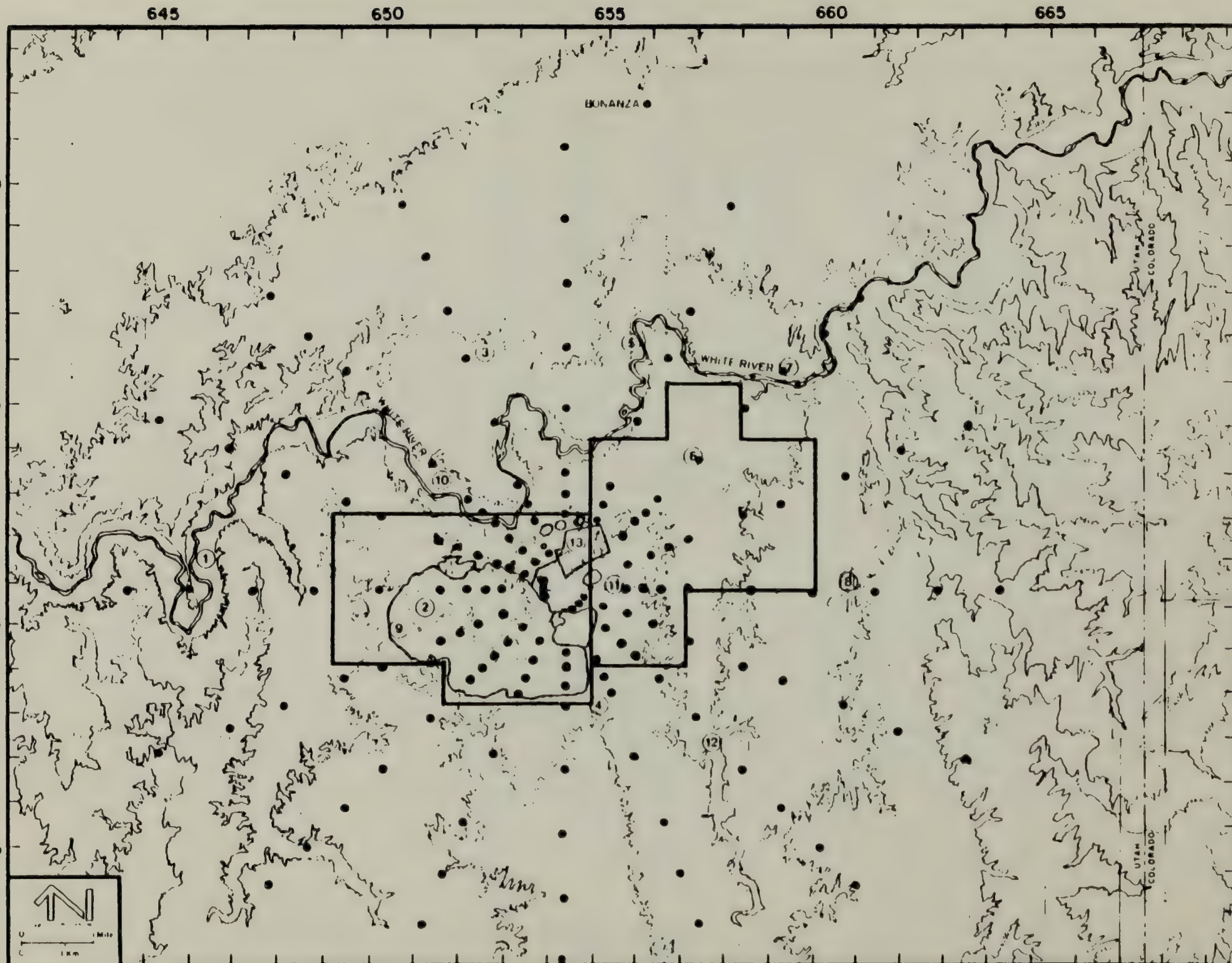


Figure 5.2-3 RECEPTOR GRID FOR PHASE I IMPACT ANALYSIS

Table 5.2-4

PHASE III SOURCE INVENTORY

Source Cat	Source Characteristics			
	Exhaust Temp. (k)	Exit Vel. (m/s)	Actual Volume Flow (m^3/s)	Area Source Width[(a)] (m)
Mine Vents	281	26.9	1537.0	—
	281	26.9	1537.0	—
	281	26.9	1537.0	—
	281	26.9	1537.0	—
Transfer Points	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
	281	17.6	2.8	—
Coarse Shale St	281	—	—	145
	281	—	—	145
Secondary Crush	281	20.2	5.5	—
Fine Shale Stoc	281	—	—	125
Fines-Retort Pr and Ball Heat	327	36.3	27.9	—
	327	36.3	27.9	—
Indirect-Retort Boiler	422	26.1	38.5	—
	450	57.8	1218.0	—
Shale Disposal	281	—	—	1250
	281	—	—	1250
	281	—	—	1250
	281	—	—	1250
	281	—	—	800

(a) Coordinate the width.

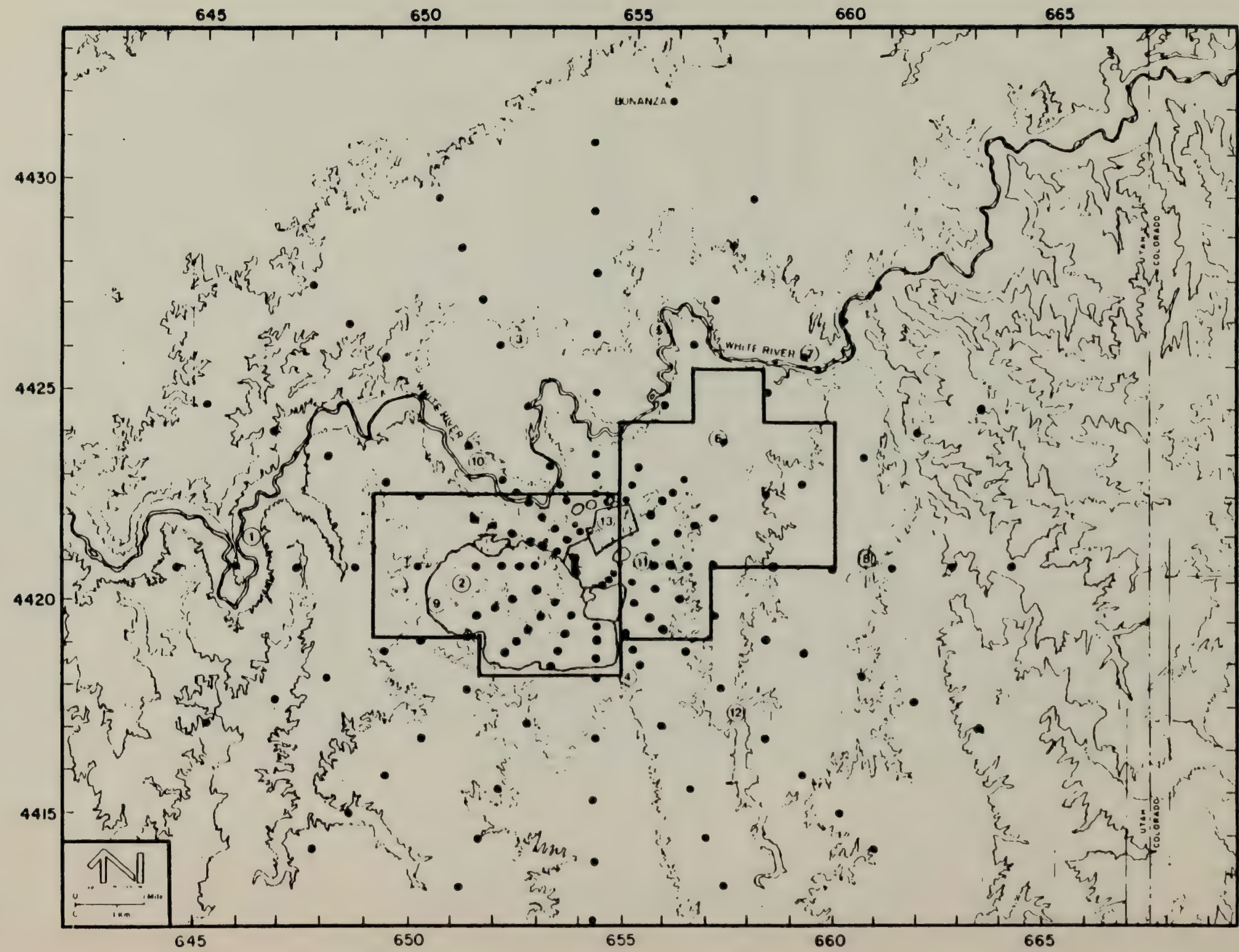


Figure 5.2-3 RECEPTOR GRID FOR PHASE I IMPACT ANALYSIS

PHASE III SOURCE INVENTORY

Source Category	UTM Coordinates Zone 12[a]		Ground Elevation (ft above MSL)	Emission Rates (g/s)						Source Characteristics					
				Annual			Short Term			Source Height (m)	Stack Diam. (m)	Exhaust Temp. (k)	Exit Vel. (m/s)	Actual Volume Flow (m^3/s)	Area Source Width[a] (m)
	(km E)	(km N)		TSP	SO_2	NO_x	TSP	SO_2	NO_x						
Mine Vents	654.83	4421.32	5325	1.53	1.10	15.4	1.70	1.22	17.10	0.0	8.53	281	26.9	1537.0	—
	655.63	4421.54	5605	1.53	1.10	15.4	1.70	1.22	17.10	0.0	8.53	281	26.9	1537.0	—
	653.67	4420.85	5485	1.53	1.10	15.4	1.70	1.22	17.10	0.0	8.53	281	26.9	1537.0	—
	654.29	4420.96	5560	1.53	1.10	15.4	1.70	1.22	17.10	0.0	8.53	281	26.9	1537.0	—
Transfer Points	654.32	4421.39	5480	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	654.25	4421.58	5465	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	654.24	4421.60	5465	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	654.24	4421.61	5465	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	654.24	4421.61	5465	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	654.23	4421.64	5460	0.05	—	—	0.06	—	—	15.2	0.45	281	17.6	2.8	—
	654.18	4421.77	5350	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	653.99	4421.92	5280	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	654.29	4421.83	5340	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	654.31	4421.79	5400	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	653.87	4421.46	5315	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	653.35	4421.33	5455	0.01	—	—	0.01	—	—	15.2	0.45	281	17.6	2.8	—
	654.48	4421.62	5355	0.12	—	—	0.14	—	—	15.2	0.45	281	17.6	2.8	—
	654.60	4421.67	5380	0.12	—	—	0.14	—	—	15.2	0.45	281	17.6	2.8	—
	654.72	4421.71	5345	0.12	—	—	0.14	—	—	15.2	0.45	281	17.6	2.8	—
	654.53	4421.69	5340	0.12	—	—	0.14	—	—	15.2	0.45	281	17.6	2.8	—
	654.64	4421.73	5335	0.12	—	—	0.14	—	—	15.2	0.45	281	17.6	2.8	—
	654.76	4421.78	5410	0.12	—	—	0.14	—	—	15.2	0.45	281	17.6	2.8	—
Coarse Shale Stockpile	654.34	4421.25	5405	0.15	—	—	0.18	—	—	7.0	—	281	—	—	145
	654.36	4421.11	5455	0.15	—	—	0.18	—	—	7.0	—	281	—	—	145
Secondary Crushing	654.23	4421.32	5465	1.52	—	—	1.69	—	—	15.2	0.59	281	20.2	5.5	—
Fine Shale Stockpile	653.90	4421.32	5255	0.38	—	—	0.46	—	—	7.0	—	281	—	—	125
Fines-Retort Preheaters and Ball Heaters	654.38	4421.82	5350	3.43	0.05	3.43	3.82	0.06	3.81	61.0	0.99	327	36.3	27.9	—
	654.35	4421.85	5340	3.43	0.05	3.43	3.82	0.06	3.81	61.0	0.99	327	36.3	27.9	—
Indirect-Retort Heater	654.40	4421.61	5375	0.09	0.06	2.39	0.10	0.07	2.65	30.5	1.37	422	26.1	38.5	—
Boiler	655.12	4421.53	5445	10.90	7.77	97.10	12.10	8.63	107.90	76.2	5.18	450	57.8	1218.0	—
Shale Disposal	652.00	4418.40	5480	2.12	0.90	12.40	2.36	1.00	13.80	60.0	—	281	—	—	1250
	653.25	4418.40	5520	2.12	0.90	12.40	2.36	1.00	13.80	60.0	—	281	—	—	1250
	652.55	4419.65	5400	2.12	0.90	12.40	2.36	1.00	13.80	60.0	—	281	—	—	1250
	653.80	4419.65	5600	2.12	0.90	12.40	2.36	1.00	13.80	60.0	—	281	—	—	1250
	652.75	4420.90	5480	0.87	0.37	5.06	0.96	0.41	5.62	60.0	—	281	—	—	800

(a) Coordinates for area sources are the coordinates of the SW corner of a square area whose side length is given as the width.

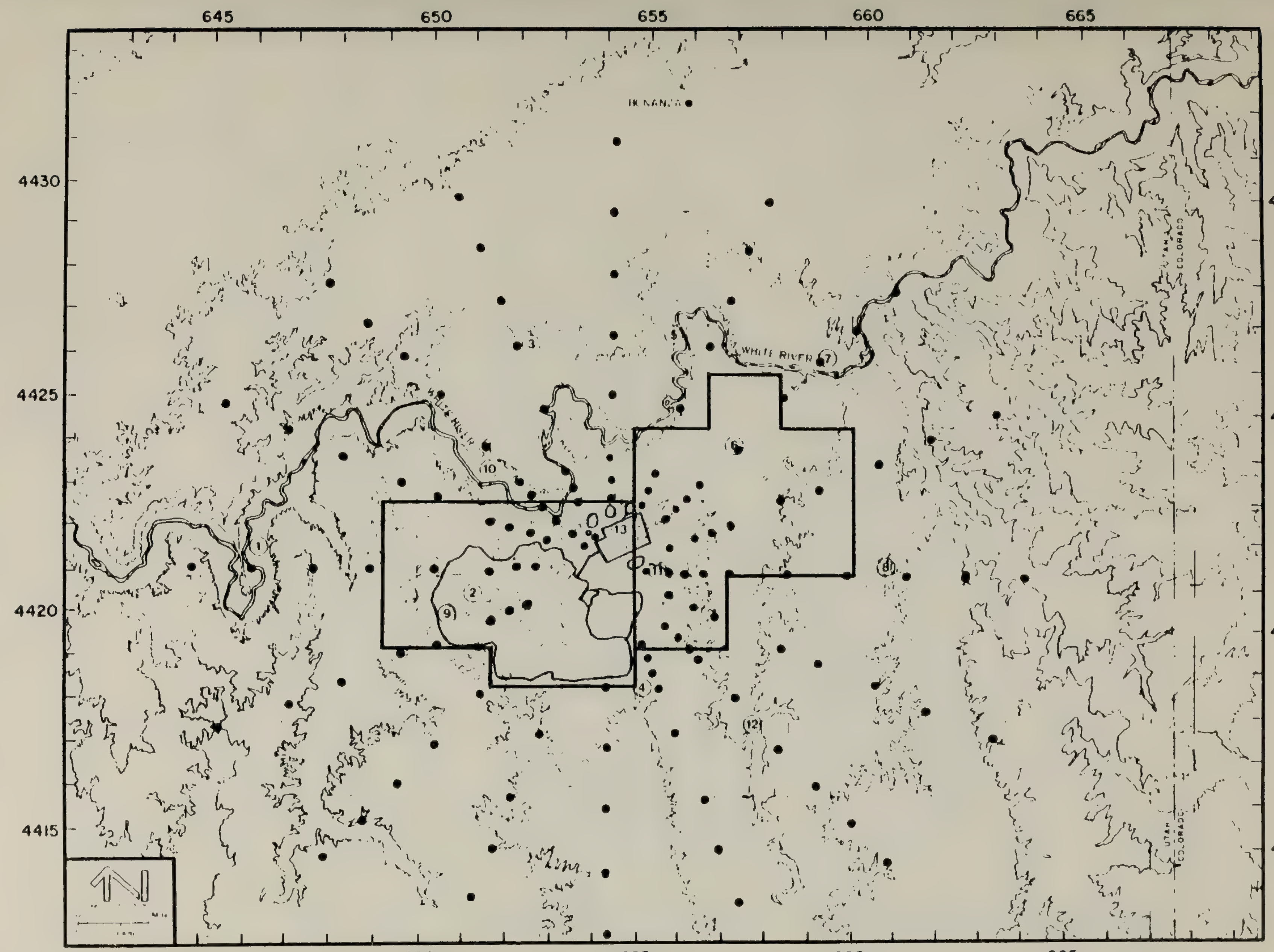


Figure 5.2-4 RECEPTOR GRID FOR PHASE III IMPACT ANALYSIS

The ground elevation at each receptor provided input to one section of the complex-terrain algorithm of VALLEY — simulation of diversion around or into obstacles. A second effect of rough terrain on diffusion was represented by incorporating the terrain roughness into the dispersion coefficient formulation, as discussed in Subsection 5.2.2.3.

The parameter for terrain roughness, σ_{tr}, is determined by finding the average standard deviation of terrain height when read every 0.5 mile along 7.5-mile segments surrounding the region of interest, as presented in Reference 5-6. The terrain roughness around Tracts Ua and Ub was calculated as 192 meters and was included as a parameter in the calculations of σ_z versus downwind distance for each plume.

5.2.3.4 Background Concentrations

Annual average concentrations at Site A6 for each of the 5 years of the baseline monitoring program for each pollutant are presented in Section 2.4. The background air quality at the WRSP site is best represented by the average of the annual averages over this 5-year period. Thus the background concentrations for NO_2, SO_2, and TSP are 3 $\mu g/m^3$, 1 $\mu g/m^3$, and 19.5 $\mu g/m^3$, respectively. These were used along with projected increments in comparisons with the NAAQS.

5.2.4 PREDICTED ANNUAL AVERAGE IMPACTS

Predicted above-background annual average TSP, SO_2, and NO_2 isopleths for Phase I are shown in Figures 5.2-5 to 5.2-7 and isopleths for the same pollutants for Phase III are shown in Figures 5.2-8 through 5.2-10. Table 5.2-5 gives the maximum predicted annual average impacts and the locations for each.

5.2.4.1 Phase I

The maximum TSP increment of 4.2 $\mu g/m^3$ was predicted to occur near the fines stockpile and is well below the PSD Class II allowable increment of

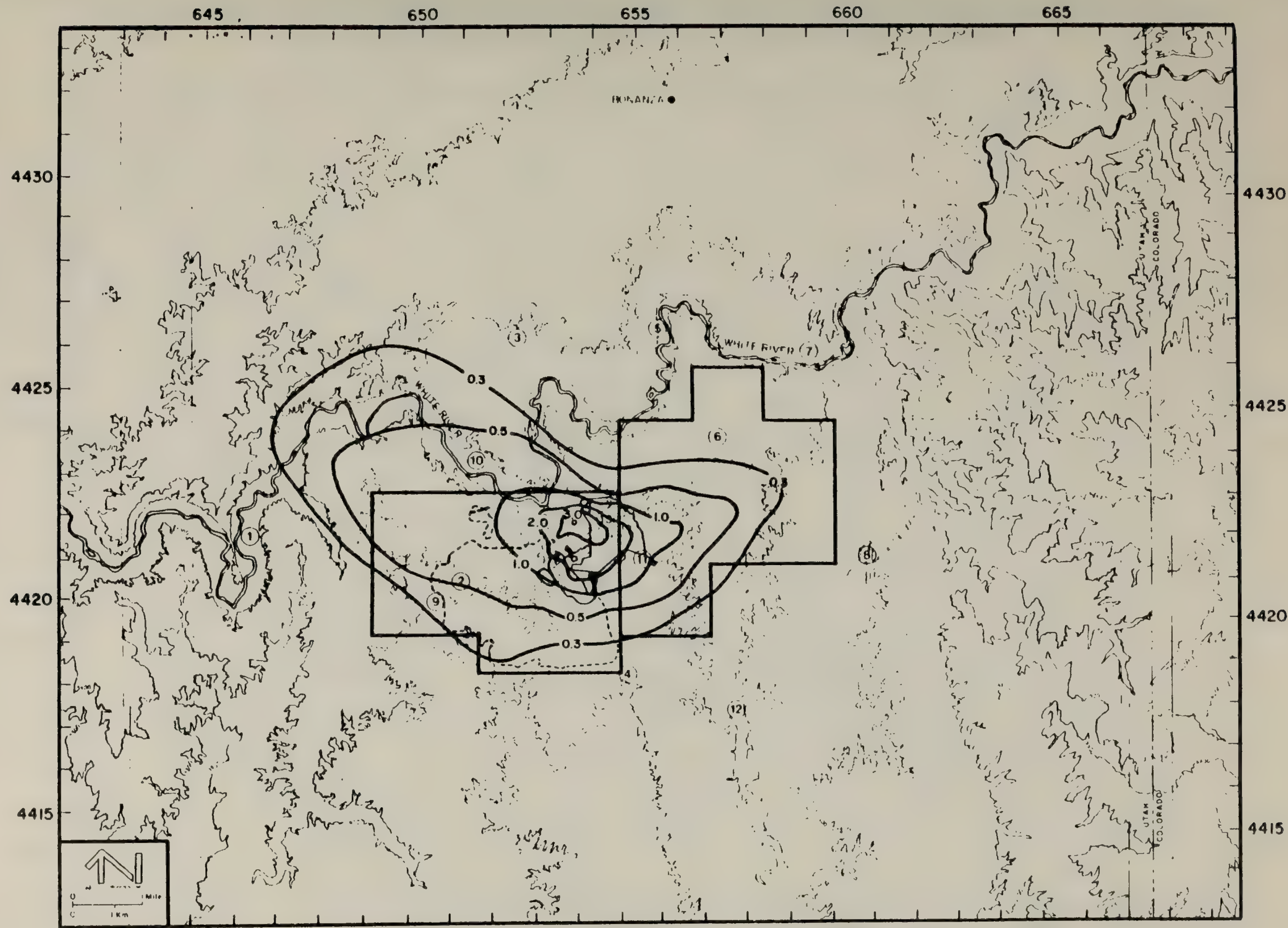


Figure 5.2-5 ISOPLETHS OF PHASE I TSP ANNUAL-AVERAGE INCREMENTS ($\mu g/m^3$)

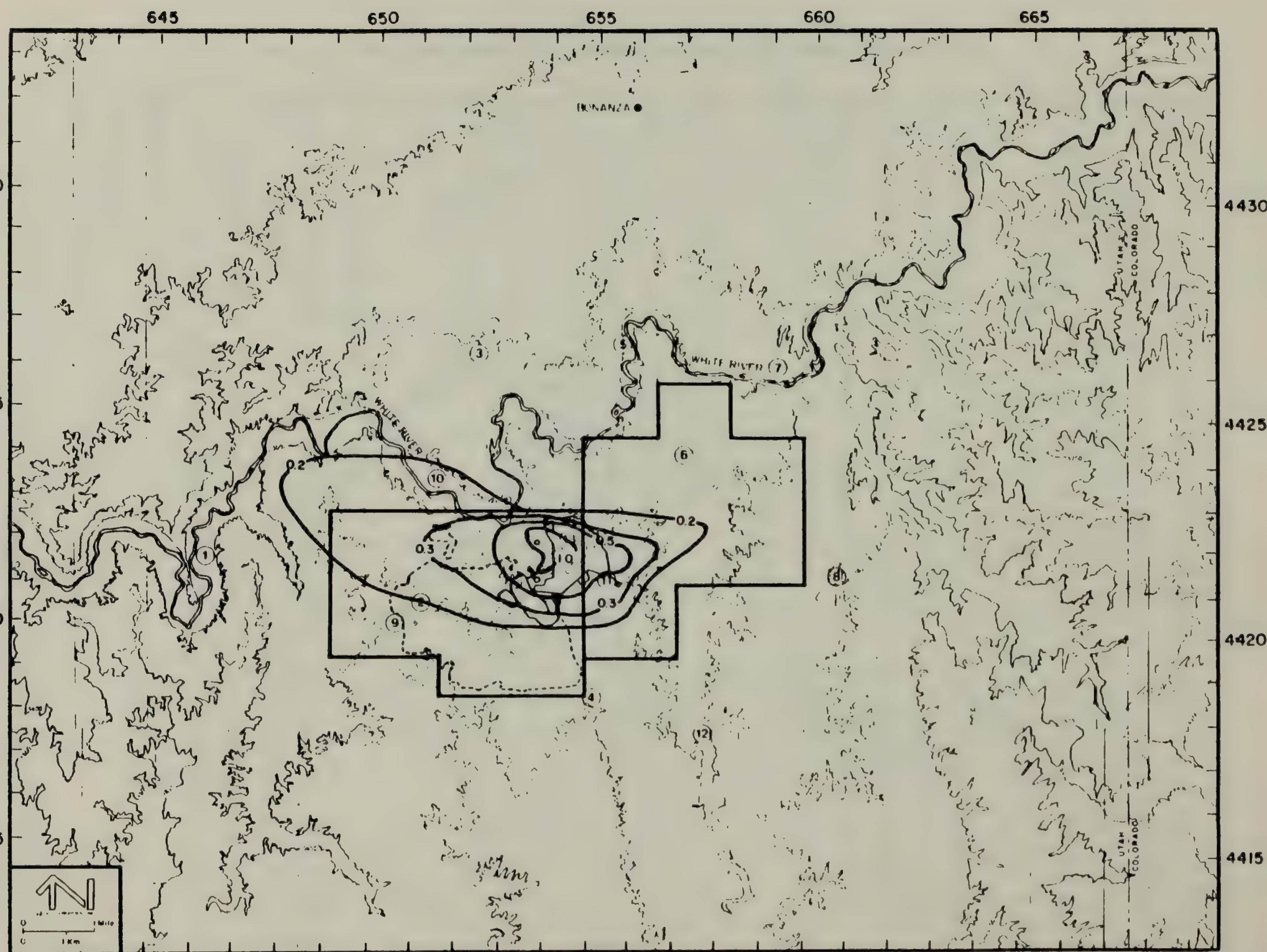


Figure 5.2-6 ISOPLETHS OF PHASE I SO_2 ANNUAL-AVERAGE INCREMENTS ($\mu g/m^3$)

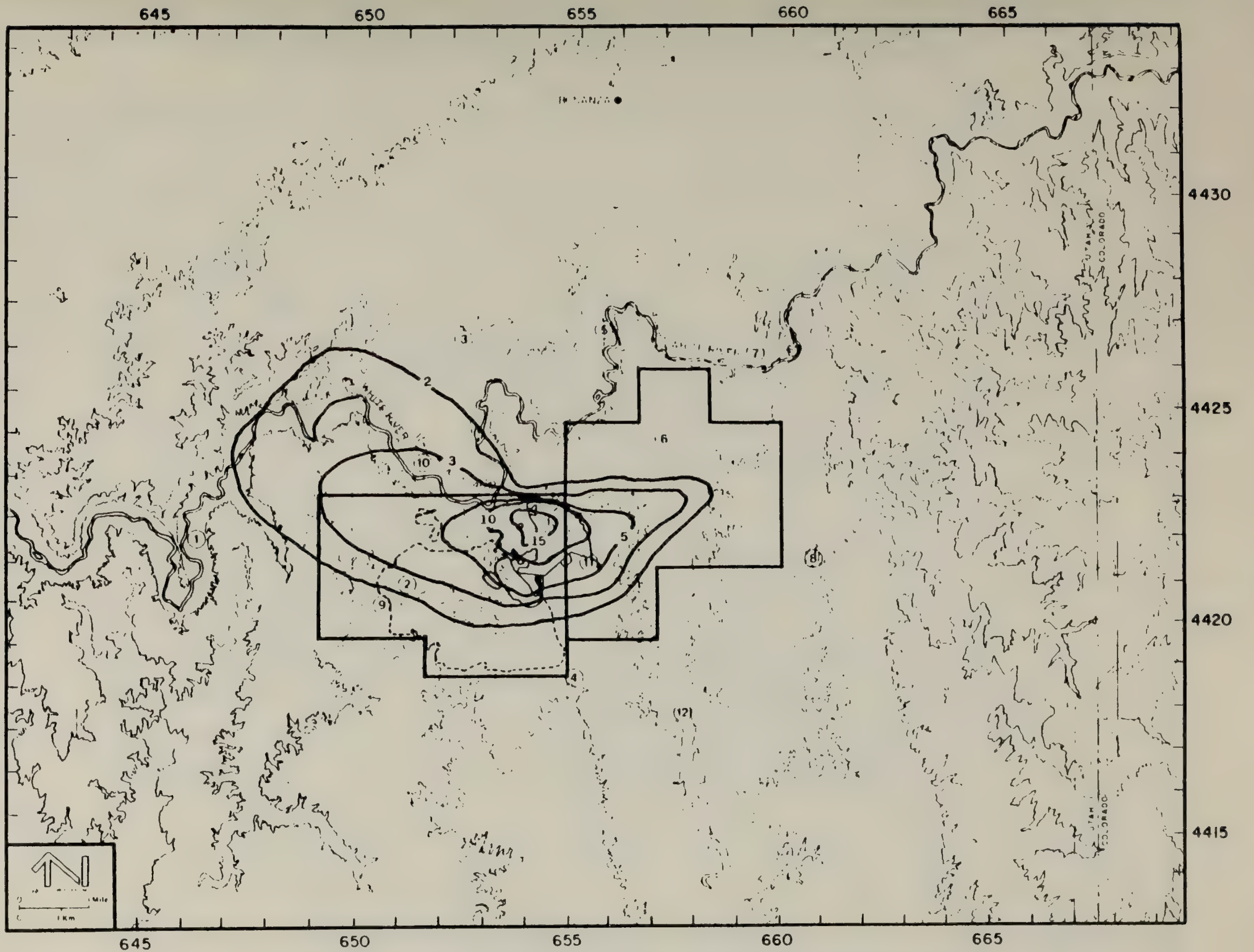


Figure 5.2-7 ISOPLETHS OF PHASE I NO_2 ANNUAL-AVERAGE INCREMENTS ($\mu g/m^3$)

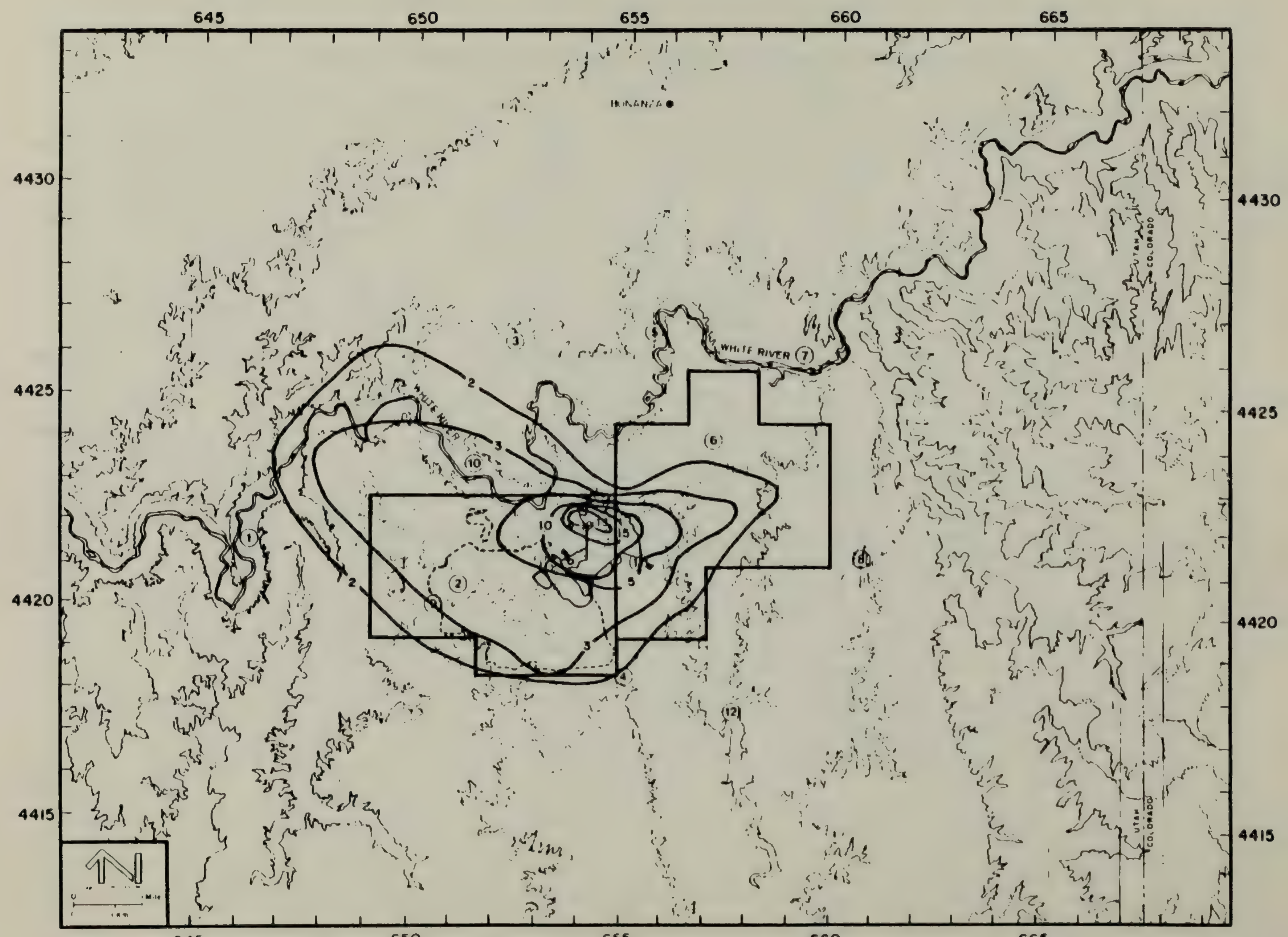


Figure 5.2-8 ISOPLETHS OF PHASE III TSP ANNUAL-AVERAGE INCREMENTS ($\mu g/m^3$)

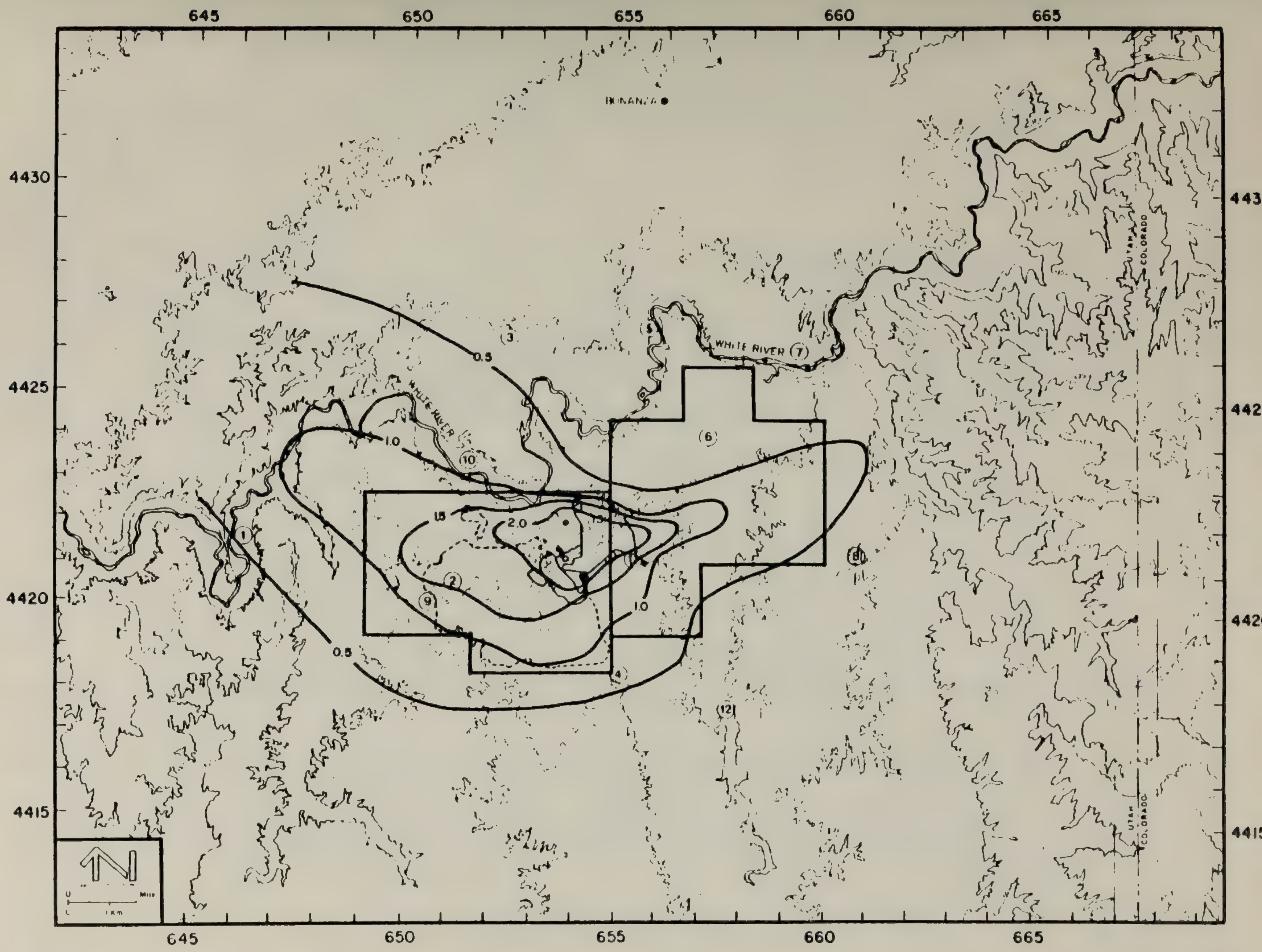


Figure 5.2-9 ISOPLETHS OF PHASE III SO_2 ANNUAL-AVERAGE INCREMENTS ($\mu g/m^3$)

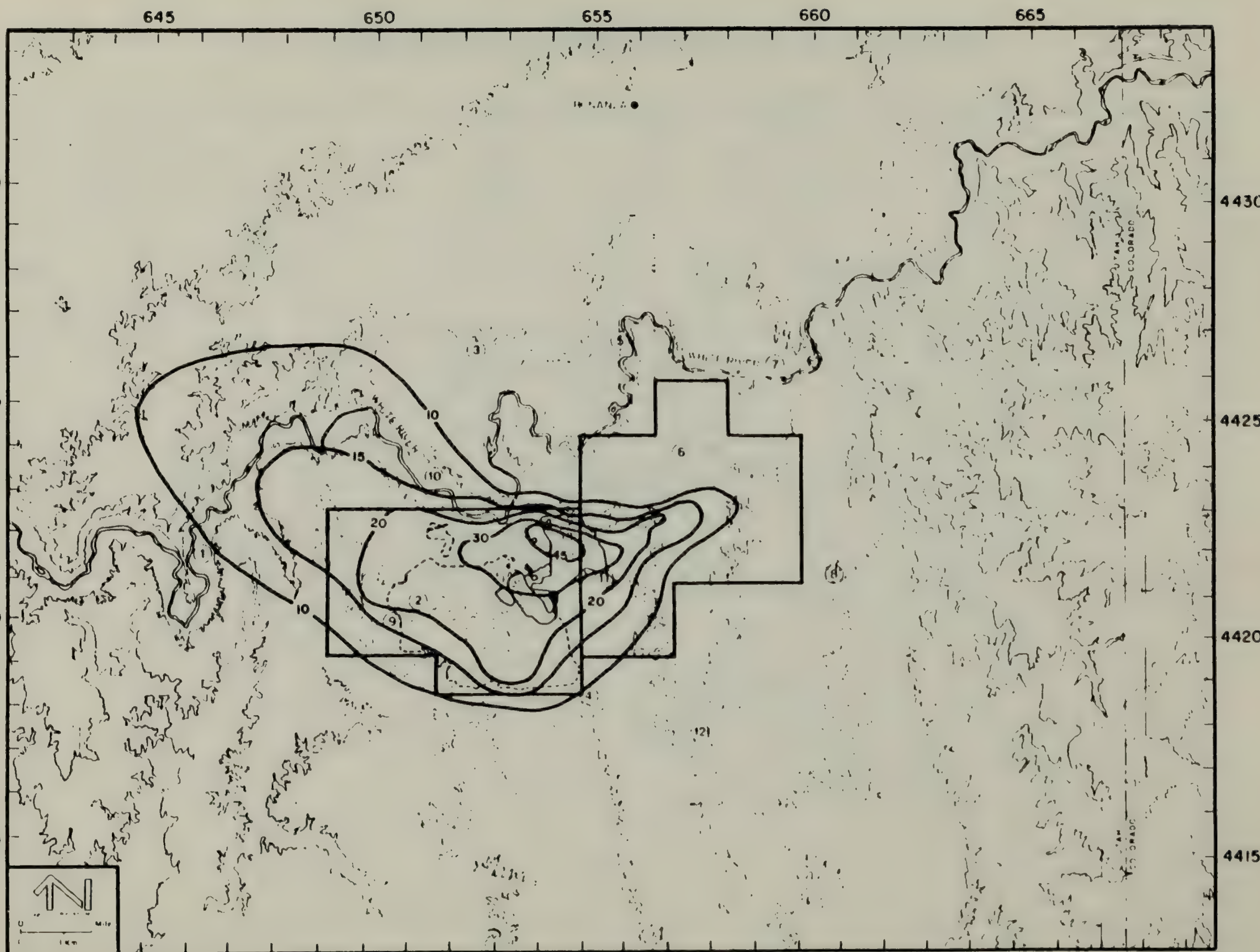


Figure 5.2-10 ISOPLETHS OF PHASE III NO_2 ANNUAL-AVERAGE INCREMENTS ($\mu g/m^3$)

Table 5.2-5

MAXIMUM PREDICTED ANNUAL AVERAGE CONCENTRATIONS, LOCATIONS, AND APPLICABLE STANDARDS

Pollutant	Development (Phase)	Maximum Impact ($\mu g/m^3$)		Receptor Location[(a)] UTM, Zone 12 (km)	Distance from Nearest Source (m)	Applicable Standards ($\mu g/m^3$)	
		With Background	Increment			NAAQS[(b)]	PSD (II)[(c)]
TSP	I	23.7	4.2	653.5E,4422.2N	480	60	19
	III	40.0	20.5	653.5E,4422.2N	480		
SO_2	I	2.3	1.3	653.5E,4422.2N	695	80	20
	III	3.6	2.6	653.5E,4422.2N	500		
NO_2	I	22.4	19.4	653.7E,4421.8N	480	100	--
	III	50.3	47.3	653.5E,4422.2N	500		

(a) These locations are all on Tracts Ua and Ub.

(b) NAAQS are secondary standards for TSP and NO_2 and primary standards for SO_2 and should be compared to "With Background" values.

(c) PSD standards are to be compared with the increment expected to accumulate from all PSD sources in the area and cannot be compared directly with the WRSP increment, although the cumulative increment is not expected to be much higher. The Class II PSD standard is quoted.

19 $\mu g/m^3$ and also below the PSD Class I standard of 5 $\mu g/m^3$. The value inclusive of background is 23.7 $\mu g/m^3$, less than 40 percent of the NAAQS standard of 60 $\mu g/m^3$.

The maximum SO_2 increment of 1.3 $\mu g/m^3$ would occur at the same location as the maximum TSP impact. The nearest SO_2 source to the point of maximum impact would be the incinerator. This concentration is below the maximum allowable PSD SO_2 increment of 20 $\mu g/m^3$. Including background, the highest SO_2 concentration is predicted to be 2.3 $\mu g/m^3$, less than 3 percent of the federal standard of 80 $\mu g/m^3$.

The maximum increment of NO_2 would also occur near the incinerator and is predicted at 19.4 $\mu g/m^3$. There are currently no PSD incremental standards for NO_2. If background is included, the maximum concentration is predicted at 22.4 $\mu g/m^3$, less than 25 percent of the 100 $\mu g/m^3$ NAAQS.

The maximum off-tract increments for annual average TSP, SO_2, and NO_2 are predicted to be 1.3 $\mu g/m^3$, 0.3 $\mu g/m^3$, and 4.3 $\mu g/m^3$, respectively. All three will occur in the White River Valley at the base of the bordering cliffs, with the maxima for the gaseous pollutants approximately 1,200 meters downstream of the particulate maximum. This result can be seen on the isopleth plots mentioned above.

5.2.4.2 Phase III

The predicted maximum TSP increment of 20.5 $\mu g/m^3$ is located near the fines stockpile on the cliffs overlooking the portion of the White River contained within Tract Ua. This is slightly above the PSD Class II standard of 19 $\mu g/m^3$. The TSP increment falls to below the standard in another 40 meters at 520 meters from the fines pile and below 5 $\mu g/m^3$ at the tract boundary. Including background, a maximum of 40.0 $\mu g/m^3$, two-thirds the federal secondary standard of 60 $\mu g/m^3$, is predicted.

The maximum predicted SO_2 increment in Phase III is 2.6 $\mu g/m^3$, which is below the PSD Class II increment of 20 $\mu g/m^3$. This impact is located near the site of the Phase III TSP maximum described above. The predicted maximum concentration of 3.6 $\mu g/m^3$, including background, will be less than 5 percent of the 80 $\mu g/m^3$ federal standard.

The maximum NO_2 concentration predicted, 50.3 $\mu g/m^3$ (47.3 $\mu g/m^3$ increment), is approximately 50 percent of the NAAQS 100 $\mu g/m^3$ maximum allowable. This highest impact is located near the sites of both the other Phase III maxima reported above.

The predicted maxima off-tract, Phase III annual average increments for TSP, SO_2, and NO_2 are 5.3 $\mu g/m^3$, 1.3 $\mu g/m^3$, and 19.4 $\mu g/m^3$, respectively. The TSP maximum is predicted to occur at the base of the north-facing cliffs where the White River enters Tract Ua. The SO_2 and NO_2 maxima locations are predicted to be in the same place, at the base of the west ridge of Southam Canyon, at an elevation of 5,200 feet.

5.2.5 PREDICTED WORST-CASE SHORT-TERM IMPACTS

Worst-case meteorology for short-term (24-hour) analyses consisted of the coupled wind speed/stability category set of 2.0 meters per second and stability F. Worst-case wind direction was evaluated by simulating all directions for each scenario with the modified VALLEY model and using the direction that produced the consistently highest off-tract concentrations. Table 5.2-6 gives the highest 24-hour average impacts and indicates the meteorology used for each case. TSP and SO_2 are the only pollutants discussed in this section, since there is no short-term standard for NO_2. Figures 5.2-11 through 5.2-14 depict plots of worst-case concentration versus distance for the 24-hour average model runs.

The plots show 24-hour average worst-case concentrations by directional vector from the radial grid center at 654 km E and 4421 km N, UTM

Table 5.2-6

MAXIMUM PREDICTED 24-HOUR AVERAGE CONCENTRATIONS, LOCATIONS, AND APPLICABLE STANDARDS[a]

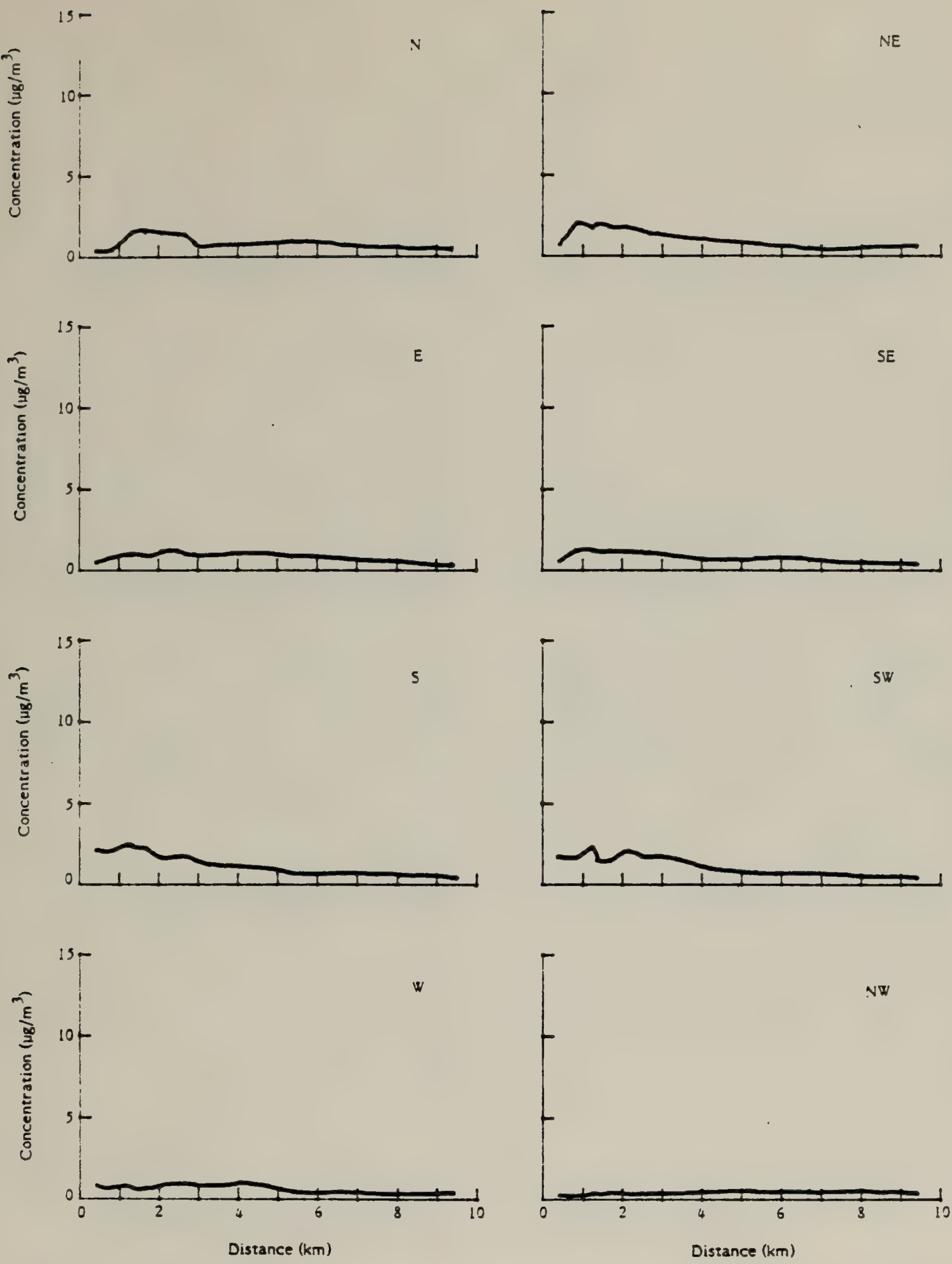
Pollutant	Development Phase	Maximum Impact ($\mu g/m^3$)		Receptor Location[b] UTM, Zone 12 (km)	Distance from Nearest Source (m)	Applicable Standards ($\mu g/m^3$)	
		With Background	Increment			NAAQS[c]	PSD (II)[d]
TSP	I	26.1	6.6	654.8E,4421.0N	320	150	37
	III	43.9	24.4	654.8E,4421.0N	180		
SO_2	I	4.5	3.5	654.6E,4420.7N	610	365	91
	III	4.1	3.1	654.7E,4419.4N	150		

(a) Worst-case meteorology for Phase III SO_2 is stability category F with a north-northeasterly wind of 2.0 m/sec. All other worst-case scenarios were identical, except the wind direction was northerly. Does not include impact of non-WRSP sources.

(b) These locations are all on Tracts Ua and Ub.

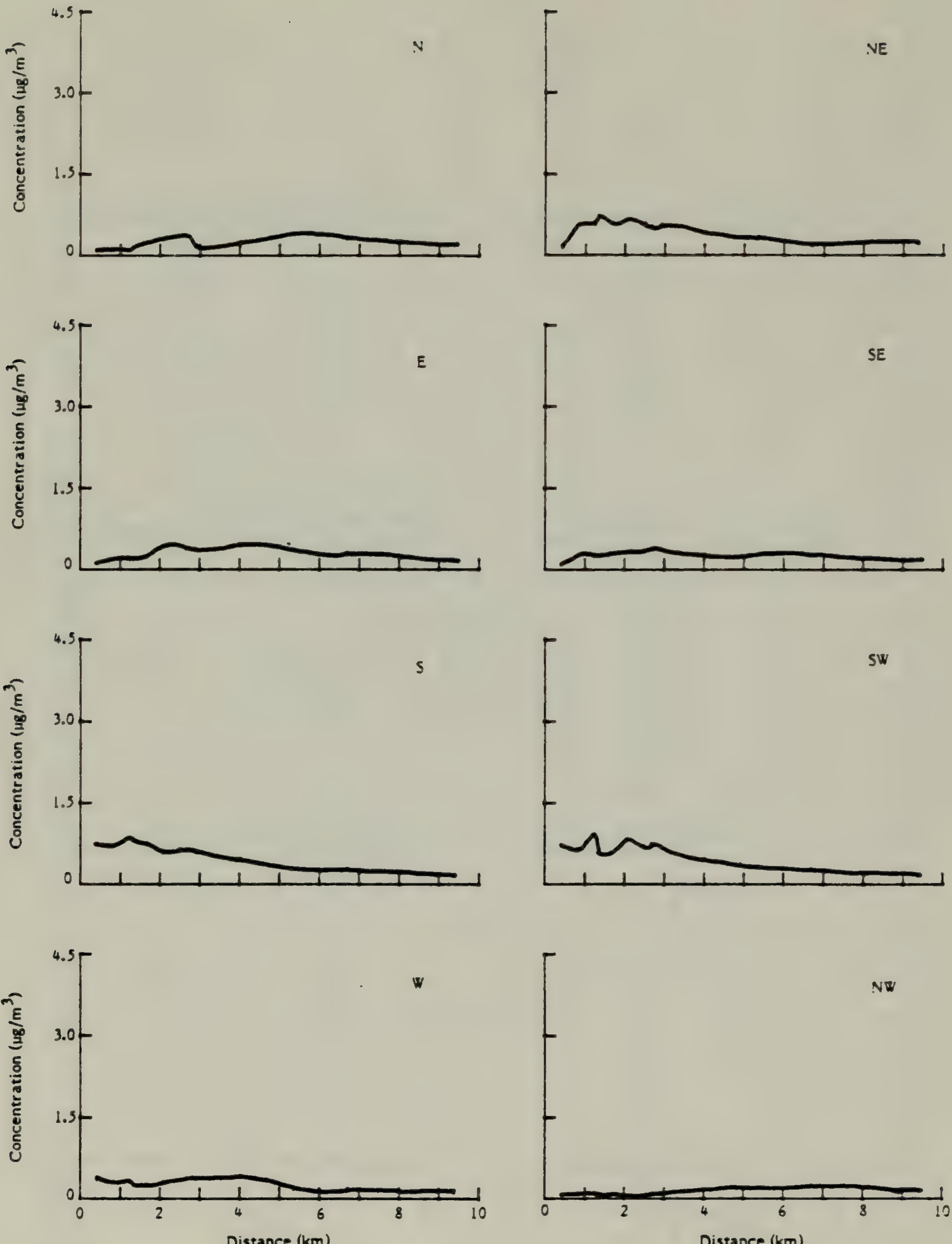
(c) The NAAQS presented are secondary for TSP and primary for SO_2 and are to be compared to the "With Background" impacts.

(d) PSD standards are to be compared with the increment expected to accumulate from all PSD sources in the area and cannot be compared directly with the WRSP increment although the cumulative increment is not expected to be much higher. The Class II PSD standard is quoted.



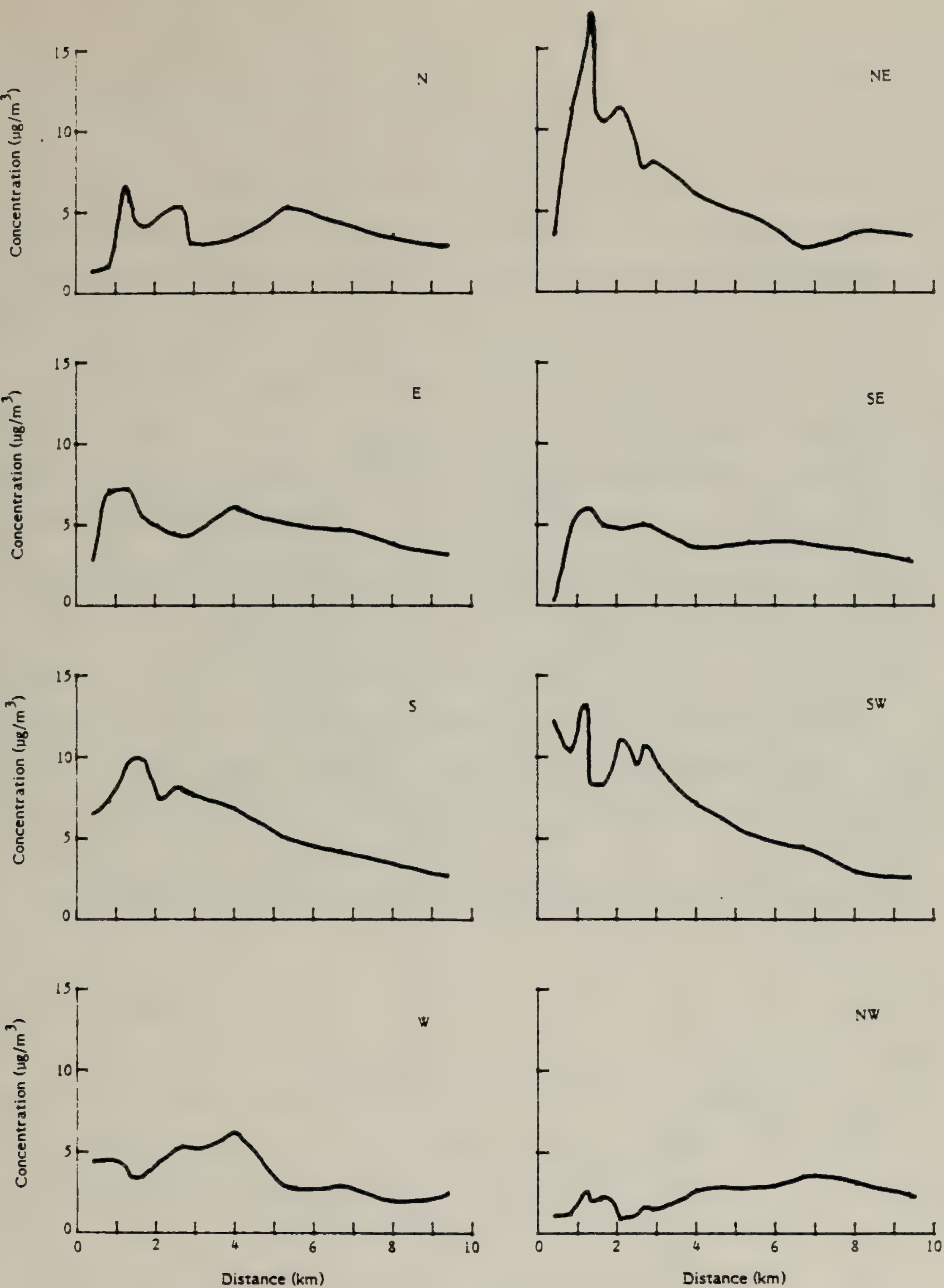
NOTE: Origin represents approximate center of all source locations, with various maxima caused by outlying sources along the radial.

Figure 5.2-11 PLOTS OF PREDICTED WORST-CASE TSP 24-HOUR AVERAGE CONCENTRATION VERSUS DISTANCE FOR PHASE I



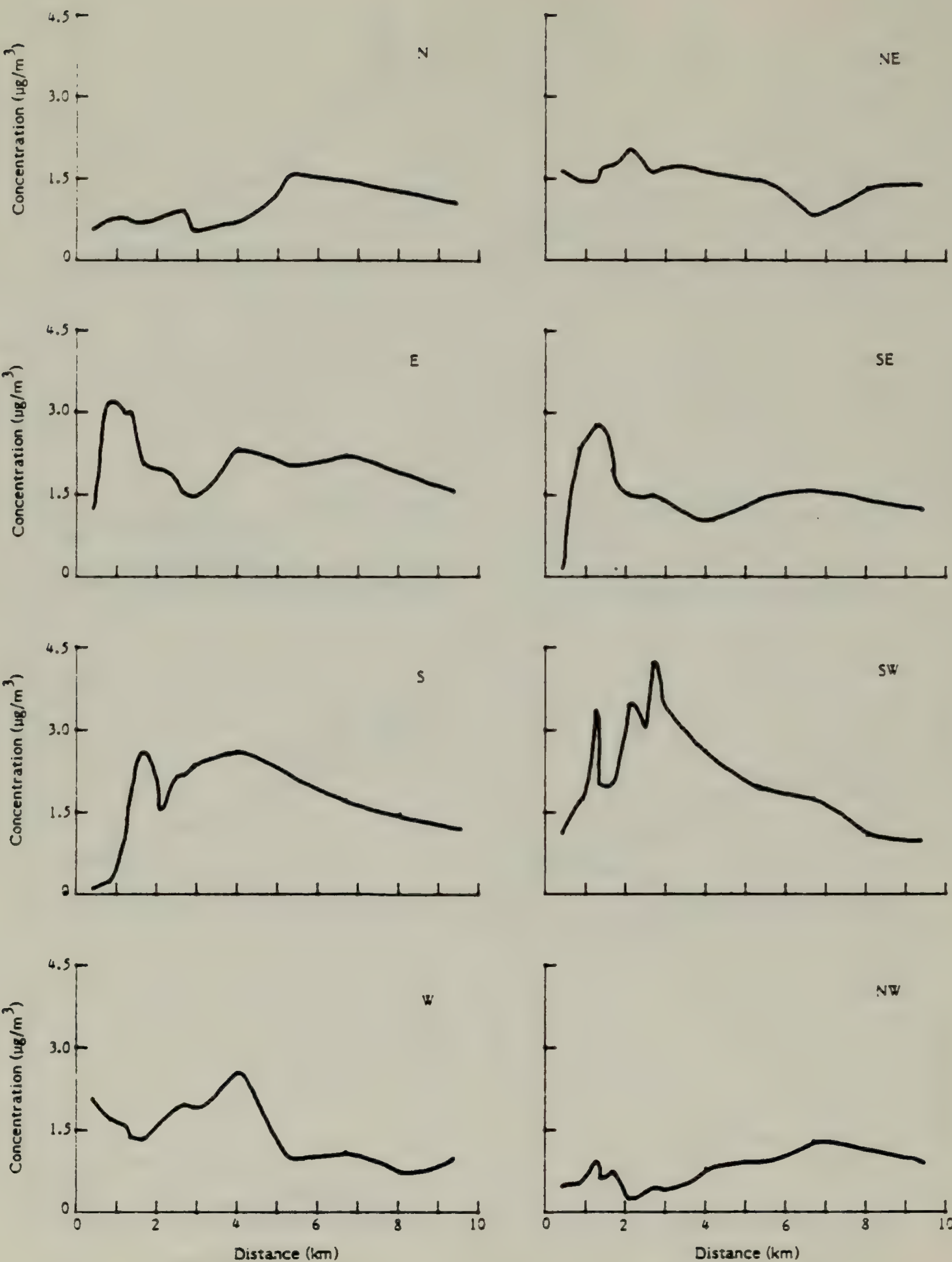
NOTE: Origin represents approximate center of all source locations, with various maxima caused by outlying sources along the radial.

Figure 5.2-12 PLOTS OF PREDICTED WORST-CASE SO_2 24-HOUR AVERAGE CONCENTRATION VERSUS DISTANCE FOR PHASE I



NOTE: Origin represents approximate center of all source locations, with various maxima caused by outlying sources along the radial.

Figure 5.2-13 PLOTS OF PREDICTED WORST-CASE TSP 24-HOUR AVERAGE CONCENTRATION VERSUS DISTANCE FOR PHASE III



NOTE: Origin represents approximate center of all source locations, with various maxima caused by outlying sources along the radial.

Figure 5.2-14 PLOTS OF PREDICTED WORST-CASE SO_2 24-HOUR AVERAGE CONCENTRATION VERSUS DISTANCE FOR PHASE III

coordinates. Since all phases of operation of the WRSP involve many air pollutant sources, this grid center was chosen as the spatial average of all source locations, including the shale disposal sites. All receptor radials shown in Figures 5.2-3 and 5.2-4 were used for determining short-term averages in each wind direction. Concentrations were plotted for only the radials directly opposite to the wind direction from each of the eight compass points. In some cases, these particular plot choices do not show maximum concentrations for the particular wind direction due to the fact that the radials plotted were not directly along the source-receptor plume centerlines. However, the plots do present relative distributions of concentrations in each of the directions. The discussion that follows addresses maximum impacts regardless of on which radial they occur. All plots show concentration increasing with distance from grid center, passing through one or several maxima depending on source geometry relative to the radial, and then decreasing with further distance. Impacts at receptors out to 20 km were calculated and in all cases the concentrations decreased steadily past about 9 km from grid center. In several cases, local maxima occurred beyond the source areas, corresponding to locations where the plume would impinge on elevated terrain. The concentrations predicted to occur within 10 km of the origin are in all cases greater than concentrations due to impingement at further distances.

5.2.5.1 Phase I

For TSP, the worst-case wind direction was found to be from the north. The highest 24-hour average TSP increment of 6.6 $\mu g/m^3$ was predicted to occur near the mine vent and represents plume impingement at the 5,600-foot level of the steep hills south of the process area. This increment is well below the Class II PSD allowable increment of 37 $\mu g/m^3$. Including background, the prediction becomes 26.1 $\mu g/m^3$, which is less than 20 percent of the NAAQS secondary standard of 150 $\mu g/m^3$. The frequency of occurrence of this meteorology (2-meter-per-second wind from the north with F stability) for any single hour based on the 5-year data base is less

than 0.03 percent of the time. It can safely be expected that the frequency of occurrence of 24 hours of this meteorology is much less than 0.0015 percent of the days in any given year.

The highest frequency of occurrence of F stability with any wind direction at 2-meter-per-second speed is 3 percent of the times for a single hour of occurrence. This occurs with ESE winds. The total frequency of occurrence of F stability with 2.0-meter-per-second wind for any given hour is 5 percent. Short-term SO_2 averages had the same worst-case wind direction. The maximum 24-hour average SO_2 increment of 3.5 $\mu g/m^3$ is also predicted to occur near the mine vent and is well below the Class II PSD allowable increments of 91 $\mu g/m^3$ for this averaging time. This impact with background is 4.5 $\mu g/m^3$, which is less than 2 percent of the NAAQS value. The 3-hour averages consistent with the 24-hour averages predicted by VALLEY were assumed to be larger by a factor of four. This factor was derived from considerations of the meteorological persistence assumed in VALLEY. The maximum 3-hour average SO_2 increment is thus predicted as 14 $\mu g/m^3$ or 15 $\mu g/m^3$ with background, less than 2 percent of the 1300 $\mu g/m^3$ NAAQS 3-hour value. This meteorology is identical to that used for the Phase I TSP scenarios and the frequency of occurrence is bounded from above by 0.0015 percent of the days or less than 0.01 percent of the 3-hour periods in any given year.

5.2.5.2 Phase III

The worst case 24-hour average TSP increment predicted was 24.4 $\mu g/m^3$ in the same location as the maximum predicted for Phase I TSP in the short term. This value is below the PSD Class II standard of 37 $\mu g/m^3$ and the impact with background of 43.9 $\mu g/m^3$ is below 30 percent of NAAQS secondary level of 150 $\mu g/m^3$. The meteorology for the worst case is again the same as the Phase I short term TSP scenario and is expected to occur much less than 0.0015 percent of the days in a year.

The maximum 24-hour average SO_2 increment for Phase III of 3.1 $\mu g/m^3$ was predicted to occur near the junction of Tract Ua and the southwest corner of Tract Ub. This increment is less than the maximum expected in Phase I for SO_2 because the location of maximum impact predicted for Phase I would be within the shale disposal pile planned for Phase III. (Receptors within source areas, such as the shale disposal pile, were eliminated from the impact assessment.) With background, the maximum would be 4.1 $\mu g/m^3$ and no standards are expected to be exceeded. The worst-case meteorology for this scenario (2 meter-per-second wind from north-northeast coupled with F stability) is predicted to occur less than 0.02 percent of the of the year for any single hour and the frequency-of-occurrence for 24 continuous hours will be much less than 0.001 percent of the days in any given year.

The maximum 3-hour average impact for SO_2 is predicted to be four times higher than the 24-hour average, or 12.4 $\mu g/m^3$. With background, the maximum 3-hour average is 13.4 $\mu g/m^3$. Neither the PSD increments nor the NAAQS would be exceeded. The upper bound of the frequency of occurrence of the worst case meteorology is 0.001 percent of the days or less than 0.007 percent of the 3-hour periods in any given year.

5.2.6 PROJECT IMPACTS ON PRISTINE AREAS

The nearest Class I area to Tracts Ua and Ub is the Flat Tops Wilderness Area, some 130 kilometers to the east. Dinosaur National Monument, however, is approximately 55 kilometers to the north of the proposed project, and has been under consideration for redesignation as a Class I area (Figure 5.2-1). Impacts for the PSD criteria pollutants were calculated using modified VALLEY at receptors at the southern border of Dinosaur National Monument in order to predict the upper limit of the increments attributable to project air pollutant emissions at pristine areas. It is expected that impacts at Flat Tops will be less than the values projected for Dinosaur because of the greater distance.

The receptors chosen for study were located on the southern border of Dinosaur National Monument at its point of closest approach to Tracts Ua and Ub. The south-facing ridge at this border varies in altitude from 5,200 to 7,400 feet above sea level. Receptors at various altitudes in this range were studied at points along the monument boundary, 15 kilometers north of the junctions of U.S. 40 and Utah 45. The highest impacts for all time averages were predicted to occur at the 5,700-foot level as a result of plume impaction.

Annual average increments for Phase I were predicted to be 0.001 and 0.003 $\mu g/m^3$ for SO_2 and TSP, respectively. The corresponding values for Phase III are 0.007 and 0.02 $\mu g/m^3$. These impacts are well under 1 percent of the Class I PSD increments shown in Table 4.2-3.

The highest expected 24-hour average increments would occur under a 2.0-meter-per-second southerly wind during stability class F, with a projected frequency of occurrence of less than 0.0001 percent of the days in a year. The values predicted are 0.02 and 0.04 $\mu g/m^3$ for Phase I SO_2 and TSP, respectively, and 0.13 and 0.29 $\mu g/m^3$ for Phase III SO_2 and TSP, respectively. These maximum impacts are less than 5 percent of the Class I 24-hour average PSD incremental standards.

SO_2 and TSP impacts at Flat Tops Wilderness Area are expected to be much less than those projected for Dinosaur National Monument.

In addition to considering the SO_2 and TSP impacts, visibility is also of concern for this project. With respect to the two areas discussed here (Flat Tops and Dinosaur), a "first level analysis" for visibility impacts was performed. This analysis procedure is discussed in the draft document "Workbook for Estimating Visibility Impairment" (Ref. 5-12), and involves a series of conservative screening tests, using simple algorithms and nomograms provided in the workbook.

This analysis indicates that the worst conceivable visibility impact of Phase III at the Dinosaur National Monument is likely to be minimal in terms of plumes visible against the sky and plumes visible against the terrain, and is expected to be insignificant or imperceptible in its effect on the visual range and sky/terrain contrast. This should also be true at Flat Tops area, especially due to the greater distance and intervening topography.

5.2.7 MODELING SUMMARY

The maximum predicted concentrations for the pollutants TSP, NO_2, and SO_2 were compared with applicable national standards for Phase I operation. This comparison showed that no violations are expected and that Phase I impact on any Class I area is also negligible.

Similar projections and comparisons with standards for Phase III operation demonstrate significant feasibility of compliance. Only annual average TSP increments in the vicinity of the onsite fines stockpile show a possibility of exceedances. Since the nearest source, the fines pile, is planned to be depleted early in Phase III, the attainment of all standards should be possible.

The low concentrations predicted for these pollutants emitted in large amounts (TSP, SO_2, and NO_x) suggest that modeling of the lesser emitted criteria pollutants (CO and HC) is not necessary to show probable compliance with applicable air quality standards for this project.

5.2.8 NOISE IMPACTS

The following paragraphs discuss noise impacts of the project in each phase, both on tract during construction and operation and off tract.

5.2.8.1 Phase I

Construction Noise. Noise caused by construction activities will depend on day-to-day schedules, variation in equipment operation, weather conditions, and other factors. Since these variables may change from time to time during the construction period, noise level estimates and impact evaluations for construction activities are based on expected maximum or worst conditions. The noisiest activities during construction will be blasting, excavation, and clearing and grading of the site.

Since there are no residents within the tract area, the on-tract impact of construction noise will be limited to construction workers. An estimated 50 workers will be directly involved with the operation of earth-moving equipment, rock drills, and blasting activities. These personnel may be exposed to higher noise levels than others on the project.

The noise level inside the cabs of earth-moving equipment may be as high as 105 dBA, depending on the type, capacity, mode of operation, acoustical treatment, and other factors. The noise level of rock drills near the ears of the operators may exceed 100 dBA.

If the noise level were not controlled, exposure to these noise levels during a typical work shift would exceed the operational noise exposure limits specified in the federal and Utah occupational safety and health regulations as described in Section 4 of Environmental Regulations and Guidelines (Ref. 5-13). The impact on personnel will be minimized by adhering closely to the regulations and employing feasible noise control procedures and techniques (see Section 4.2.4).

Operation Noise. On-tract noise impact throughout the project will be limited to personnel working close to machinery and equipment. The noise

generated by mining, material handling, and processing is expected to be in excess of 90 dBA in certain areas. Many of these areas are accessed only occasionally during maintenance operations. Activities that can be expected to create high noise levels include mining, crushing and screening, shale loading, retorting, and upgrading. High noise exposure of workers will be limited by regulations and guidelines governing occupational noise exposures (see Section 4 of Ref. 5-13) and subsequent noise control procedures and techniques specific to the facility operation (see Section 4.2.4).

Off-Tract Noise. Off-tract noise during Phase I will be generated by three major sources: the facility construction, the facility operation, and traffic to and from the facility.

Noise generated by construction and operation of the facility itself will be attenuated by distance and atmospheric absorption, and by bluffs and rough terrain that act as natural barriers; all will provide substantial acoustic isolation to nearby communities.

Traffic-generated noise will not be confined to the facility. The impact of traffic noise will depend on traffic volumes, the path of the facility's main access road, and the proximity to nearby communities.

The nearest community is Bonanza, approximately 5 miles from the tract, and separated from the facility by rough terrain. The expected maximum excavation and blasting noise levels at Bonanza caused by construction of the Phase I facilities are shown in Table 5.2-7. Only two blasts per day are normally expected. Noise attenuation by distance, atmospheric absorption, and terrain effects are included in projecting these noise levels. It is also assumed tht the blasting noise levels will be limited by regulating the amount of explosives.

Table 5.2-7

PROJECTED MAXIMUM NOISE LEVELS AT BONANZA
CAUSED BY PHASE I CONSTRUCTION

Construction Activities	A-Weighted Sound Level (dBA)	Peak Sound Pressure Level (dB)	Peak Over-Pressure (lb/ft^2)
Excavation, Earth Moving, and Grading of Process Area	40	-	-
Blasting of Process Area and Mining and Ventilation Shafts	-	83	5.9×10^{-3}

The expected maximum noise levels are evaluated in terms of the U.S. Environmental Protection Agency (EPA) noise criteria presented in Section 4 of Reference 5-13.

When the predicted A-weighted sound level shown in Table 5.2-7 is compared with EPA criteria, the noise level at Bonanza during the noisiest stage of Phase I construction is estimated to fall within the EPA acceptable range. Similarly, when the peak overpressure of blasting noise is compared with EPA's proposed criteria, this noise is not likely to disturb the residents of Bonanza.

Because of the limited amount of equipment operating during Phase I, noise propagated off tract will not be substantial. Noise from facility operation is expected to be below the background noise levels of 25 to 30 dBA, which are typical of the area and the town of Bonanza.

The main route to and from the facility passes by the community of Bonanza. In predicting traffic noise, personnel access traffic is assumed to originate outside of the town of Bonanza and to pass through it. If all or most of the traffic originates in Bonanza, community planning will be required to minimize the noise impact to the residents.

Traffic noise will be generated by employee car and truck traffic as well as by supply truck traffic. Employee traffic during construction and operation will be limited mostly to shift changes and possibly lunch breaks. Supply truck traffic will be interspersed throughout the day.

The traffic noise is evaluated in terms of L_{50} (average level) or the noise level exceeded 50 percent of the time. This average level derived from the range of baseline data is estimated to be 30 dBA near the facility and Bonanza. The impact is based on an increase in L_{50} levels at the nearest residence in Bonanza, and the resulting levels are compared with EPA criteria.

Both construction and operation traffic noise levels fall well within the EPA acceptable range. Traffic noise during Phase I construction is expected to increase the ambient L_{50} levels to 38 to 43 dBA.

Traffic noise during Phase I operation is expected to decrease because of reduced traffic volumes. The reduced activity will account for a 10 dB decrease in average noise levels to 28 to 33 dBA at the nearest residence.

5.2.8.2 Phase II

Construction Noise. Approximately 70 workers will be directly involved with the operation of earth-moving equipment, rock drills, and blasting activities during the noisiest stage of Phase II construction. Noise levels and impacts to those workers are similar to those described for Phase I.

Operation Noise. The number of noise sources during Phase II operations will be significantly greater than Phase I because of increased capacity, additional processing, and associated increase in pieces of equipment. Phase II operation is also expected to expand and intensify areas of excessive occupational noise levels over Phase I. Because of the new equipment and processes employed, a revision of Phase I noise control techniques and procedures may be necessary to limit employee noise exposures.

Off-Tract Noise. The expected maximum excavation and blasting noise levels at Bonanza caused by Phase II construction activities are shown in Table 5.2-8. A comparison of these expected maximum noise levels with EPA criteria shows that no significant noise impact on the residents of Bonanza is expected during Phase II construction.

Facility operation during Phase II will involve a large number of noise sources that will generally increase noise levels (over those of Phase I) near the process area and other parts of the facility. Noise propagated to the off-tract community of Bonanza is expected to increase only marginally. Noise levels at the nearest residence in Bonanza during facility operations are projected to be 25 to 30 dBA, well within the range of measured background levels.

Traffic volumes are expected to peak during this period because of the simultaneous influx of construction and operating personnel and supplies. A projected increase of 18 to 25 dBA above existing L_{50} noise levels is expected at the nearest residence in Bonanza. This increase may be less than indicated, depending on the extent of bus transportation used in lieu of individual passenger cars. Nevertheless, the resulting L_{50} levels of 48 to 53 dBA are low and fall within the EPA acceptable range.

Table 5.2-8

PROJECTED MAXIMUM NOISE LEVELS AT BONANZA
CAUSED BY PHASE II CONSTRUCTION

Construction Activities	A-Weighted Sound Level (dBA)	Peak Sound Pressure Level (dB)	Peak Over-Pressure (lb/ft^2)
Excavation, Earth Moving, and Grading of Process Area	41	-	-
Blasting of Process Area and Mining and Ventilation Shafts	-	96	2.63×10^{-2}

5.2.8.3 Phase III

Construction Noise. Approximately 25 workers will be directly involved with the operation of earth-moving equipment, rock drills, and blasting activities during the noisiest stage of Phase III construction. Noise impacts on these workers are similar to those described for Phase I.

Operation Noise. An increase in the number of noise sources will accompany the increased output capacity of the facility. Noise levels may increase in certain worker areas where the augmented capacity dictates larger concentrations and greater intensities of major noise sources. But since Phase II and III processes are similar, specific noise control strategies and procedures established for Phase II should be readily adaptable to limit employee noise exposures during Phase III.

Off-Tract Noise. The noise level at Bonanza during Phase III construction will be affected both by construction and by Phase II operation. The expected maximum total noise levels under this condition are presented in Table 5.2-9.

Table 5.2-9

PROJECTED MAXIMUM NOISE LEVELS AT BONANZA
DURING PHASE II OPERATION AND PHASE III CONSTRUCTION

Construction Activities	A-Weighted Sound Level (dBA)	Peak Sound Pressure Level (dB)	Peak Over-Pressure (lb/ft^2)
Excavation, Earth Moving, and Grading of Process Area, and Operation of Phase III Facilities	35	-	-
Blasting of Process Area and Mining and Ventilation Shafts	-	86	8.3×10^{-3}

When Phase III construction is completed and heavy construction machinery is removed, noise levels will decrease. Levels of 28 to 33 dBA are expected at the nearest residence in Bonanza as a result of Phase III operation. These levels are within or slightly above the range of existing background levels. The facility-generated noise is expected to be barely audible at most and will probably be indistinguishable from the existing ambient level in Bonanza.

As the project nears completion, traffic volume and noise caused by construction personnel will decrease. The L_{50} levels of 29 to 34 dBA projected at the nearest residence in Bonanza are a result of traffic noise during the full-scale Phase III operation. These levels are well within the EPA acceptable range.

5.2.8.4 All Phases: Noise Effects on Wildlife

Auditory sensing (perception of ground vibration and airborne sound) and visual and olfactory sensing are necessary for wildlife survival. It is difficult to determine the degree to which noise contributes to wildlife disruption, since it varies considerably among wildlife species.

Noise effects on wildlife fall into two categories: 1) migration of noise-sensitive species to quieter areas, and 2) acclimatization of wildlife to the higher noise environments.

Initial wildlife disruption is not, in the strictest sense, a noise effect. The sound from construction, operation, and transportation activities of the proposed facilities is perceived by wildlife as warning information; noise is defined as unwanted sound that hampers the transfer of information. Nonetheless, the effects of noise from the project can be expected to combine with visual and olfactory evidence of the increased presence of

humans to displace wildlife from current habitats. Little reliable information is currently available to document the expected extent of such specific noise-induced disruption upon wildlife around Tracts Ua and Ub.

Numerous observations, however, have been documented on the ability of many wildlife species to adjust to noisier areas. Typical examples are flocks of birds at noisy refuse disposal areas, at airports, and at rocket-testing grounds, and the occurrence of deer and other wildlife in some urban areas.

5.3 EFFECTS ON WATER RESOURCES

Construction and operation of the mine and processing facilities will produce changes in the water resources of Tracts Ua and Ub. Alterations in surface drainage will occur as a result of project activities. Contaminated surface runoff will be intercepted and contained by retention dams in Southam Canyon (processed shale disposal area) and by the wastewater holding basin (plant site). Contaminated water that infiltrates into the alluvium will be contained upstream of the dam structures and is not expected to reach the bedrock aquifers. The flow regime of Southam Canyon will be changed; however, this should not have a significant effect on the flow regime of the White River. Mine dewatering is not expected to have a significant effect on groundwater hydrology.

5.3.1 PHASE I

5.3.1.1 Construction Effects

Surface Water Hydrology. Approximately 295 acres of land will be disturbed during Phase I. (The total area of the tracts is 10,240 acres.) Changes in surface relief resulting from site preparation will alter runoff patterns; also, the rate and quantity of runoff will be increased due to site paving and other activities that will decrease permeability. Temporary and permanent drainage control facilities will be built at the plant site, and along pipelines and access roads, as described in Section 4.5. Surface runoff from the plant site drainage will be retained by the wastewater holding basin after its construction. The drainage areas affected by construction activities are small compared with the total drainage area for the tracts. The construction activities during this phase should not significantly affect the surface water hydrology of these drainages (e.g., White River, Evacuation Creek, Southam Canyon, and Asphalt Wash).

Surface Water Quality. Construction activities will increase the potential for erosion of a portion of the disturbed land surfaces. Drainage control

facilities and temporary sediment retention structures should minimize the transportation of sediment to the White River and Evacuation Creek. Construction of the water intake pumping station on the White River may produce localized sediment concentrations that are higher than normal. These potential effects should be temporary, since revegetation and soil stabilization efforts will be initiated as soon as practicable. No other effects are anticipated.

Groundwater Hydrology. No significant alluvial aquifers are located within the area to be disturbed for construction of the plant site and auxiliary facilities. Mine shafts will pass through the Bird's Nest Aquifer. These shafts will be lined and grout-sealed near water-bearing zones to prevent hydrologic connection with the mining zone. This should ensure confinement of the aquifer and minimize dewatering requirements. The amount of water removed from the Bird's Nest Aquifer in the vicinity of the mine shafts is expected to be negligible compared with the groundwater in storage. The overall effect of construction activities on the groundwater hydrology of the tracts should be insignificant.

Groundwater Quality. Considering the conditions described above, there should also be no significant effect on the groundwater quality due to construction activities.

5.3.1.2 Operation Effects

Surface Water Hydrology. Surface runoff from the plant site will be retained by the wastewater holding basin for later use in process activities. Surface runoff and any alluvial flow from the processed shale disposal area will be contained by the retention dam immediately down-gradient from the disposal area. This water will be removed from the pond within a short time and used for dust suppression and compaction of the processed shale. These impoundments will prevent a portion of the runoff from the drainages on the tracts from reaching the main channels of Southam Canyon and the

White River. The remaining portions of the drainages on the tracts will not be affected during Phase I. Flow reductions for the drainages on the tracts will be negligible compared with the normal total contribution to the White River, because the impounded drainage area is a small portion of the total area for the tract drainages.

Water is expected to be available from the State of Utah's dam and reservoir on the White River. If the reservoir is not available, water will be withdrawn from the White River alluvium north of the plant site by a system of shallow wells. These wells will be recharged directly by the White River. The average withdrawal rate (1,400 gpm) is quite small compared with the 10-year, 7-day low flow of the White River (56,100 gpm or 125 cfs).

In summary, Phase I operations will have some effect on the surface water hydrology of the drainages on the tracts, but are not expected to have a significant effect on the hydrology of the White River.

<u>Surface Water Quality</u>. The plant site runoff and wastewater contained by the wastewater holding pond will be contaminated. Also, the runoff contained by the retention dam located down-gradient from the processed shale disposal area is expected to be contaminated due to contact with processed shale, sanitary landfill material, and other non-hazardous waste materials disposed of in the pile. (The characterization of pollutants and sources for Phase I operations will be similar to that described for Phase III in Section 5.3.2.) Contaminated water will not reach the uncontaminated downstream surface water drainages unless the design capacities of the impoundments are exceeded or the water escapes by leaking through cutoff walls in the dams. Section 4.5 describes the design features and capacities of the project impoundments that should prevent contaminated water from being discharged. It is expected that the design features of these impoundments will be sufficient to minimize the possibility of detrimental effects on downstream surface water quality. No effects on surface water are

anticipated in the remainder of the tract drainages during Phase I operations and prior to Phase II construction, since they will not be disturbed between the completion of Phase I construction and the start of Phase II construction.

Groundwater Hydrology. There are no significant alluvial aquifers in the immediate vicinity of the proposed plant site and processed shale disposal area. However, contaminated water (from contact with the processed shale and other non-hazardous waste materials disposed of in the pile) will be able to infiltrate into the alluvium upgradient of the retention dam. A cutoff wall in the embankment of the dam is expected to prevent the contaminated water from reaching the alluvium downgradient of the retention dam. Percolation of water from the alluvium into the Uinta Formation is retarded by the relative impermeability of various zones within the formation. These zones also act as confining layers that retard downward movement of water from the Uinta Formation into the Bird's Nest Aquifer and restrict the upward movement of the water from the Bird's Nest Aquifer.

The mining zone is below the Bird's Nest Aquifer and above the Douglas Creek Aquifer. Minimal amounts of dewatering are expected during the mining operations of Phase I.

Based on these observations, it is anticipated that Phase I operations will not significantly affect the groundwater hydrology of the tracts.

Groundwater Quality. The quality of the alluvial water up-gradient of the retention dam will probably be degraded by the contaminated runoff and leachate from the processed shale disposal area. It is expected that the remainder of the groundwater in alluvial and bedrock aquifers of the tracts will not be affected.

5.3.1.3 Effects Off Tract

Phase I activities are not expected to significantly affect surface water and groundwater hydrology or quality in areas outside of the boundaries of Tracts Ua and Ub. Water will be withdrawn from the White River Reservoir.

5.3.2 PHASES II and III

5.3.2.1 Construction Effects

Surface Water Hydrology. Construction effects during expansion to Phases II and III will be similar to those described for Phase I. As more land is cleared and paved or developed, more drainage control facilities will be built. These facilities are described in Section 4.5. The overall effects on surface water hydrology of the tracts should be minor.

Surface Water Quality. The effects on surface water quality due to construction activities during Phases II and III will also be similar to those in Phase I. The additional drainage controls are expected to minimize the temporary increases in sediment transportation to the White River.

Groundwater Hydrology. The mining and ventilation shafts constructed during Phases II and III will be lined and grout-sealed to confine the groundwater zones that are above the mining operations. Mine dewatering is expected to be minimal. These activities should have a negligible effect on groundwater hydrology.

Alluvial groundwater may be encountered during construction of the retention dam near the mouth of Southam Canyon. Construction activities at this site may require temporary dewatering of this alluvial aquifer, if water is encountered.

No other effects on groundwater hydrology of the tracts are anticipated.

Groundwater Quality. Effects on groundwater quality are expected to be limited to potential degradation of alluvial groundwater near the mouth of Southam Canyon (due to construction of the retention dam). This effect will be temporary and should not have a significant effect on water quality within the White River alluvium.

5.3.2.2 Operation Effects

Surface Water Hydrology. During Phases II and III, changes in surface water hydrology will occur because of the obstruction of the drainage in Southam Canyon by the retention dam near the mouth of the canyon, the withdrawal of fresh water from the White River, and other drainage control features on the tracts.

The retention dam in Southam Canyon will prevent contaminated runoff and processed shale leachate from reaching the White River. The impoundment will be designed to contain the surface runoff from a 100-year storm in the Southam Canyon drainage. Any water that is impounded at this location will be removed within a short time and used for dust suppression and compaction of the processed shale.

The deposit of processed shale will eventually become a barrier to surface runoff from the portion of the Southam Canyon drainage upstream of Tract Ua. The runoff impounded at this site will also be removed within a short time after accumulation and used in dust suppression and compaction of the processed shale. Also, the top of the finished pile will be contoured into depressions to collect precipitation in shallow sinks for use in revegetation (see Section 3.10). These depressions will be designed to contain the volume of water from a 100-year storm.

The wastewater holding basin north of the plant site will continue to be used as an impoundment to contain surface runoff from the plant site and some of the wastewater from project operations. This water is used in process activities.

An on-tract freshwater reservoir located upstream of the plant site (to the south) will be used for fresh water storage. The dam will be designed to contain the runoff from a 100-year storm.

The total drainage area to be impounded during Phase III amounts to approximately 5,300 acres. The streamflow records for Station 09306610 indicate that the average annual runoff of Southam Canyon during water years 1975 through 1979 was 11.9 acre-feet from a drainage area of 5,310 acres; the streamflow records for Station 09306500 indicate that the average annual flow of the White River (as it passes the tracts) during the same period was 453,000 acre-feet.

Based on these observations, the flow reduction of the White River due to the impoundment of the tributaries discussed above will be negligible compared with the normal flow of the White River.

The surface water hydrology of Evacuation Creek and Asphalt Wash will not be affected by operations in Phases II and III, since these drainages will not be disturbed to any significant extent.

During Phases II and III, water will be withdrawn from the White River reservoir. This will amount to an average of 8,600 gpm (19 cfs) during dry weather operation during Phase II. During Phase III, this quantity will be increased to an average of 16,800 gpm (37 cfs).

Surface Water Quality. Storms and snowmelts within Southam Canyon drainage will produce intermittent and measurable surface runoff and leachate that will be contaminated by contact with the deposited processed shale. This water will be contained behind the retention dam near the mouth of Southam Canyon. (For further details on the processed shale disposal plan and the retention dam, refer to Sections 3.10 and 4.5.)

The potential pollutants and sources relevant to full-scale commercial production (Phase III) were investigated in a study for the EPA (Ref. 5-14).

In this study, a preliminary ranking of both the pollutants and sources was developed. The three basic criteria used to develop the ranking related to: 1) volume of waste, persistence, toxicity, and concentration, 2) mobility of pollutants, and 3) known or anticipated harm to water use.

The highest priority potential pollutant sources associated with the processed shale disposal area involved the processed shale itself, and the high-TDS wastewater, stripped sour water, and retort water that will be used to moisten the processed shale. Since the retention dam is located below the processed shale disposal area, these were also the highest ranked sources for the retention dam. The potential pollutants from these sources that ranked highest included dissolved solids, selected macroinorganics (sodium, sulfate, and chloride), selected trace elements (arsenic, fluorine, and selenium), ammonia, and organics (polycyclic organic materials, carboxylic acids, and phenols). Although the concentrations of these and other constituents in the contaminated runoff and leachate are uncertain, the water is expected to be marginally unfit for aquatic life or consumption by humans or wildlife.

The highest priority potential pollutant sources associated with the process area involved the wastewater holding basin, the raw shale storage area, and the tankage area. The highest ranking pollutants from these sources include dissolved solids, ammonia, arsenic, selenium, organics, oil additives, and miscellaneous fuels. Contaminated surface runoff from the raw shale storage areas (both coarse shale and fine shale) will be contained and collected for use in process activities such as dust suppression after settling and decanting. Spills in the tankage area will be contained by catchments and the wastewater holding basin. The water in the wastewater holding basin is expected to be unfit for aquatic life, and consumption by humans or wildlife.

The design features of the retention dam and wastewater holding basin are expected to be sufficient to minimize the possibility of detrimental effects on downstream surface water quality. The surface water quality

of the remainder of the tracts is not expected to be significantly affected by operations during Phases II and III.

Groundwater Hydrology. Mine dewatering during Phases II and III is expected to be minimal. Subsidence due to mining operations is also expected to be minimal. However, subsidence (however small) could cause fracturing of the rocks above the mining zone. This would result in an increase in the permeability of the overlying formations and would influence dewatering of the mine if the fracturing reached the Bird's Nest Aquifer (see Section 4.5.3).

Water percolation into the Uinta Formation from the alluvium is expected to be quite small. The only alluvial aquifer that may be affected by project operations during these phases is in the lower reaches of Southam Canyon. Any alluvial flow in this area will be contained behind the retention dam near the mouth of the canyon (due to the cutoff and foundation treatment that is part of the design of the dam) so that it will not reach the White River.

The overall effect of project operation on groundwater hydrology of the tracts is expected to be negligible.

Groundwater Quality. Contaminated water that may seep into the alluvium will be confined to the areas up-gradient of the wastewater holding basin and the Southam Canyon retention dam. Water percolation into the Uinta Formation is expected to be negligible; therefore, it is estimated that contaminated surface runoff and leachate will not affect the water quality of the bedrock aquifers.

The overall effect of project operation on groundwater quality of the tracts is also expected to be negligible.

5.3.2.3 Effects Off Tract

Water withdrawn from the White River reservoir for project operation during Phases II and III should have little effect on the river flow downstream. The drainage control features on the tracts will be designed to ensure protection of the off-tract surface and groundwater systems against contamination.

5.3.3 DECOMMISSIONING PERIOD

The plan for this period (described in Section 3.21) provides for the maintenance of the mine, the processed shale disposal area, retention dikes, dams, and reservoirs on the tracts. Considering this plan, the potential effects on water resources will probably be similar to many of the effects during project operations. However, these effects will vary depending primarily on the degree of completion of the project when decommissioning is undertaken.

5.4 EFFECTS ON BIOLOGICAL RESOURCES

This section identifies the expected major changes in the biological resources of the area and sets the stage for the design and implementation of the wildlife management plan and ongoing monitoring program. The following approach was used to assess the impacts of oil shale development on the biota of Tracts Ua and Ub.

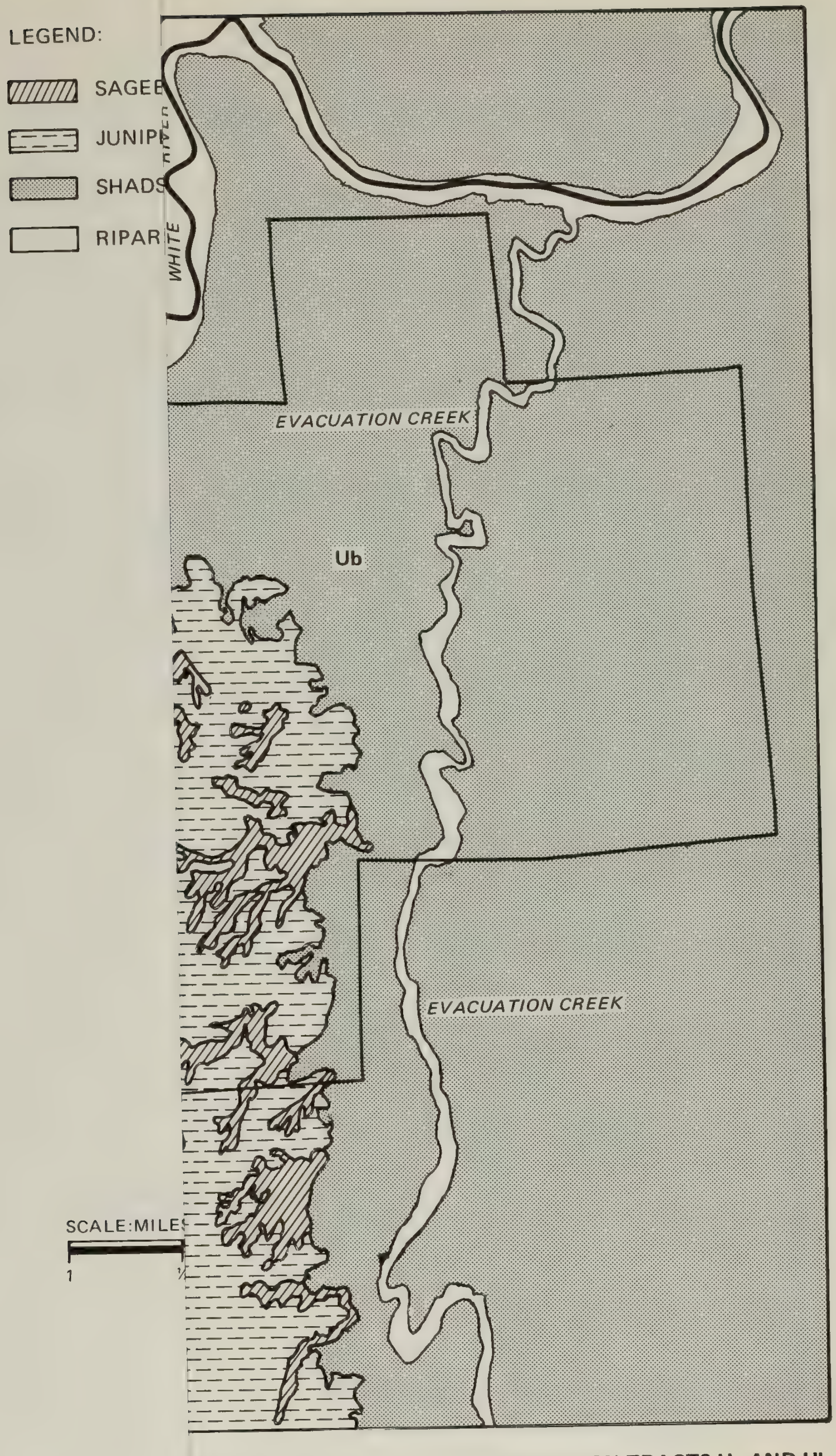
- Identify potential impacts from construction and operation of the project (Section 5.4.1)
- Discuss the responses of the major biotic groups to these impacts (Section 5.4.2)
- Discuss the changes in ecosystem structure and function that are likely to occur (Section 5.4.3)

5.4.1 POTENTIAL IMPACTS FROM CONSTRUCTION AND OPERATION

There are potential impacts to the biotic community from construction and operation of the project and from processed shale disposal. These include habitat loss; leachate from construction waste, processed shale, waste chemicals, and construction materials; dust and silt; noise from construction, operation, and traffic; air emissions; water supply requirements and wastewater; and increased human use of the tracts.

5.4.1.1 Habitat Loss

Facilities construction will directly affect about 600 acres within the process area during Phases II and III. The processed shale pile will cover approximately 2,300 acres. See Figure 5.4-1 for approximate areas of disturbance to the different vegetation types.



re 5.4-1 VEGATATION DISTRIBUTION ON TRACTS Ua AND Ub

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Figure 5.4-1 VEGATATION DISTRIBUTION ON TRACTS Ua AND Ub

5.4.1.2 Leachates

Non-hazardous waste products from construction will be disposed of in the processed shale pile. Chemicals considered hazardous will be disposed of in other approved disposal areas. Both raw and processed shale contain the cations Na^+, Ca^{++}, and Mg^{++} and the anions $SO_4^=$, $C\ell^-$, and Fl^- in concentrations on the order of parts per thousand. Trace elements, including boron, mercury, cadmium, antimony, arsenic, and selenium are in concentrations on the order of parts per million. Processed shale leachate, however, does not qualify as a hazardous waste under RCRA.

Precautions discussed herein before will be taken to limit the introduction of leachates to the aquatic systems on and adjacent to the tracts. The monitoring program discussed in Section 6 is designed to detect and evaluate the presence and effects, if any, of these leachates.

Because of the low precipitation and high evaporation rates on the tracts, water buildup in the disposal pile and subsequent leaching from the bottom is not expected to be a major problem. Experimental data indicate that no deep percolation (beyond the pull of evaporation) should occur through the compacted-shale water-harvesting surfaces that make up three-fourths of the surface area of the pile. A study in which large amounts of water were applied at frequent intervals (2.5 inches every 24 hours for 28 days) to a 90-centimeter shale column showed that 90 percent of the water evaporated, leaving only 10 percent to form a leachate (Ref. 5-15). The frequency and intensity of rainstorms on the tracts result in rainfall many times less than that simulated in these experiments. Therefore, it is expected that all the water should evaporate or transpire before percolation, even after short periods of intense rainfall.

However, it is possible that small amounts of water could move downward into the shale pile from the planting trenches because of the accumulation of runoff from the water harvesting surfaces. A stochastic computer model of water balance in the planting trenches was formulated to aid in

the prediction of this downward movement. A weakness in the model was the lack of information in the literature on water use by desert shrubs. Thus, computer runs were made assuming both extreme high and low values in order to bracket the actual value.

Assuming a low rate of water use by the plants in the soil trenches, the model predicted that during years with 10 to 12 inches of rainfall (slightly above normal), an average of 1.36 inches of percolation into the body of the shale pile would occur. Assuming a high rate of water use, the average amount of percolation during years of high precipitation was predicted to be 0.13 inch.

For years of slightly above (8 to 10 inches) and slightly below normal precipitation, which will occur most of the time, the model predicted 0.33 inch of percolation per year assuming low water use, and 0.00 inch per year assuming high water use. Thus, it would be expected that, on the average, much less than 0.5 inch per year of percolation into the shale pile would occur.

The average depth of the completed disposal pile will be 212 feet, and for any leaching to occur through the pile to its bottom, the entire depth must have been wetted, requiring about 400 inches of water. Approximately 200 inches will be applied for dust control and compacting, but only half will remain after evaporative loss. Therefore, an additional 300 inches could be absorbed without causing leaching. Assuming that an average rate of 0.5 inch of water enters the shale pile each year, it would take several hundred years to wet the entire depth of the main body. Around the edges of the shale pile, much less water will be required for wetting the profile, and leaching could occur in several years to several decades. However, the amount of this leachate should be small enough to be contained easily by the holding dam.

The surface runoff from processed shale will be contained behind the Southam Canyon retention dam. However, possible migration through underlying bedrock below the dam cannot be precluded. The leached substances present potential hazards to the terrestrial and aquatic systems if they enter the surface or subsurface water systems. To minimize the escape of leachates to the river, both the terrace system and the Southam Canyon dam will require monitoring and maintenance throughout the life of the project and after decommissioning.

5.4.1.3 Dust and Silt

Wetting the processed shale during transport and landfilling minimizes fugitive dust. Roads and parking areas will also be wetted to control dust. The water used for wetting will be treated process water, excess mine wastewater, and water from the processed shale retention dam. Fugitive dust will be generated from roadsides and landfilled processed shale. It will contain raw and processed shale compounds and particulates from exhaust emissions. This dust will be subject to transport by wind and surface runoff, and could be widely distributed throughout the tracts and surrounding area. Monitoring programs described in Section 6 are designed to detect and evaluate the effects, if any, of this source of pollutants to the biota.

Construction, with its associated earth-moving activities, could generate measurable silt loads to the drainage basins. These loadings have not been estimated at this time, but will be minimal due to erosion control measures.

5.4.1.4 Noise

The three major sources of noise are construction, operation, and traffic. Tables 4.2-8, 4.2-9, and 4.2-10 in Section 4 show estimated noise levels for these activities. Off-tract noise levels predicted for all phases of operation are within acceptable EPA, OSHA, and MSHA levels. On-tract

noise and activity near the process area, processed shale disposal, and roads will be higher and could disturb wildlife, as discussed in Section 5.2.

5.4.1.5 Airborne Emissions

All airborne emissions are intended to meet applicable federal and Utah state standards, as listed in Tables 4.2-1 through 4.2-3. Tables 4.2-4 and 4.2-6 list estimated air pollutant emissions for Phases I and III.

Airborne emissions will be generated by mining, crushing, retorting, power generation, transport, and wind movement of dusts from shale storage and disposal areas and roadways. The principal components of airborne emissions that may affect the biota are nitrogen oxides, sulfur dioxide, and particulates. These emissions will be dispersed by air currents and deposited or adsorbed onto soil and plant surfaces both on and off tract. Based upon wind patterns in the vicinity of the tracts, much of the airborne emissions generated will be circulated over the tracts and the White River.

Actual deposition patterns are difficult to predict at this time, although the calculated maximum fugitive dust deposition will occur along a zone, approximately two miles long, north by northwest from the process facilities. Airborne particulates from roadways should be concentrated near the roadways, decreasing with increasing distances from the roads. Unknown, but presumably low concentrations of these compounds will be transported by runoff into the drainage basin and ultimately to the White River.

5.4.1.6 Water Supply and Wastewater

Wastewater management practice is based on compliance with all applicable regulations. Zero discharge is planned, with all treated water recycled to process, used for dust control, or evaporated.

The Phase I construction water supply will be a well system installed near the White River. An access road approximately 2 miles long will be constructed from the existing Ignatio Stage Stop road. In addition, a pipeline corridor approximately 3 miles long will be constructed from the well system to the process area. Construction will create surface disturbances and an associated increased silt load. In addition, vegetation will be removed along the road, corridor, and at the well site. Other factors such as noise, activity, and particulates generated by traffic will occur.

The preferred alternative for water supply during Phase I operation, and both construction and operation of Phases II and III, is from a dam proposed by the state of Utah for construction on the White River near Southam Canyon (see Section 5.4.4). At present, construction of this dam is under review, due to its potential impacts upon endangered fish which may use the affected reach of the White River. Other less preferred alternatives for water supply to the project do not involve large physical changes to the river system.

5.4.1.7 Increased Human Use of the Tracts

The influx of people directly or indirectly associated with project development and operation will affect the ecosystem. The degree of impact will depend directly upon the amount of control exercised over public access and human activities in off-road areas. Uncontrolled public access could severely alter the quality of wildlife habitats.

Noise, vehicular activity, and human presence will affect wildlife, but the significance of the impact depends on the activity. Watching or following an animal will seldom cause an adverse response, such as abandonment of an area, a nest, or young. However, chasing, harassing, or shooting at an animal can cause such adverse effects. Increased noise from crushers, conveyor belts, truck traffic, and other equipment could affect a small area in the immediate vicinity, although some species considered to be

sensitive, such as mule deer, carnivores, raptors, and song birds, do not always avoid these intensive-use areas.

Recreational use of nonproject (off-road) areas is the major expected impact. Increased hunting and fishing will directly impact game and non-game populations; off-road vehicle use could lead to the greatest impacts on wildlife. Harassment, loss of vegetation, and increased soil erosion could be the mechanisms of impact.

5.4.2 RESPONSE OF MAJOR BIOTIC GROUPS TO IMPACTS

5.4.2.1 Vegetation

Direct Impacts. The White River Shale Project will affect all four vegetation types. The two major areas where existing vegetation will be displaced are:

- The site of the process facilities, where the bulk of construction activity will occur
- The processed shale disposal area and the stockpile area for fine, nonretorted shale

Process facilities will be located in the northeastern portion of Tract Ua and the western portion of Tract Ub, as shown in Figure 5.4-1. (See Table 4.5-1 for acreages.) The vegetation in the two major areas will, in effect, be removed from the regional ecological system during the 25-year life of the project. The actual loss of habitat will be progressive, however, especially in Southam Canyon, and will be partially offset by the continuing restoration of disturbed lands and the vegetation of the processed shale pile.

The biological character of the fill and process area is essentially the same; both support mixed stands of sagebrush-greasewood and juniper vegetation types in roughly the same proportions. The project will have only a minor direct impact on the highly productive riparian habitat and the

aquatic ecosystem. Riparian vegetation will be affected by the installation and operation of water supply wells and pumps during Phase I. The area of shadscale vegetation will be reduced by the installation of other project facilities, such as utilities, water and product pipelines, and access roads.

Indirect Impacts. The indirect impacts to vegetation will result from waterborne and airborne pollutants, and by altered grazing of domestic and wild animals. Although desert plants are reported to be relatively resistant to airborne pollutants, recent studies suggest that plant communities within 20 kilometers of the process area are likely to be affected. The presence of SO_2 in the concentrations expected may reduce plant germination and productivity in addition to causing accelerated leaf senescence and reduced plant growth (Ref. 5-16). Therefore, composition of the plant species may change. The change may result in the loss of some species in the area of influence or merely changes in density or cover. Changes in the annual production of species is also expected. Due to the variable responses of plants to pollutants, the productivity of some species, possibly annuals, may increase while that of other species may decrease.

Waterborne pollutants could affect plants in two ways: 1) directly from pollutants taken up through the root system, and 2) through increased salinity of the soil. These effects will most likely occur in alluvial valleys that receive runoff.

Species composition and productivity of the plant communities may be affected by a reduction in the activity of soil microbes through nutrient cycling and mycorrhizal associations.

5.4.2.2 Soil Microorganisms

Direct impacts on soil microorganisms are expected to be highly localized. Since soil microbial activity is primarily limited to surface layers and is associated with vegetative cover, the diversity, number, and activity of the microorganisms will be reduced or lost wherever topsoil is turned stored, or covered for any length of time. Localized direct impacts (i.e., habitat loss) to soil microorganisms will occur in Southam Canyon as a result of deposition of processed shale. As the processed shale reaches the bottomlands of the canyon, some of the existing soil will be removed and used as a substrate in the processed shale revegetation program. By mixing soil with the processed shale, the pile will develop a new microflora and fauna and change from an inert waste material to a more productive soil. The amount of time required for recovery depends on the degree of initial disturbance, subsequent disturbance caused by traffic and other activities, and the effect of the processed shale on the soil mixtures.

Soil microorganisms outside the Southam Canyon disposal area may be adversely affected by roadside dust distributed by wind, and airborne emissions released by retorting, internal combustion engines, and steam generation. Soils represent the principal repository of trace elements over geologic time. Therefore, the soil is the principal medium for long-term exposure of pollutants to terrestrial plants and animals. The effects of these elements on important soil microbial processes and the role of soil microorganisms in influencing the long-term availability of pollutants to plants are largely unknown. However, because some trace elements have been reported to affect adversely soil/litter communities, possible changes in microbial processes may occur. Changes in nitrogen fixation, nutrient cycling, and mycorrhizal associations have far-reaching implications for the structure and functioning of ecosystems. Because desert plants are more resistant to pollutants than plants in mesic areas, the effects on the soil microbes may be more important that the effects on the plants.

Cryptogamic crusts, which are present on the tracts, hold soil particles and reduce erosion, increase soil fertility, and improve soil structure and water infiltration in desert ecosystems. Estimates of annual nitrogen fixation by crusts have been made at 10 to 100 kg N fixed/hectare, depending on environmental conditions. Because cryptogams are particularly sensitive to air pollutants, air emissions are likely to affect these organisms on and off the tracts.

5.4.2.3 Mammals

Mule Deer (*Odocoileus hemionus*). Because of the pattern of seasonal use and distribution of the deer population on the tracts, the local deer herd will be only marginally affected by the project. Deer use of Southam Canyon is presently very light; consequently, only a minor amount of deer habitat will be lost as the canyon is filled. The process area east of Southam Canyon supports a small herd of deer year round. Construction of the process area may displace the deer in that area. As discussed in Section 4.7, alternative habitat will be established to accommodate these deer and other larger wildlife displaced by the project.

The expected influx of people and processing operations will increase ambient noise levels and other disturbances on and near the tracts. These changes in ambient conditions will initially disrupt deer activity in the uplands and in their primary summer habitat along the White River. With the construction of the White River Dam, however, the deer will be permanently displaced from the flooded riparian habitat.

Livestock. As a result of the project, approximately 2,750 acres of sheep-grazing land will be removed from Southam and Wagon Hound Allotments, some temporarily and other areas permanently (see Figure 2.5-7). As shown in Table 5.4-1, this represents a loss of approximately 642 animal unit months (AUMs), or approximately a 17 percent reduction in current grazing levels. An additional number of sheep should be restricted from the tracts as part of the enhancement program for the fish and wildlife management plan (see Section 4.7.3).

Table 5.4-1

GRAZING UTILIZATION[a]

Allotment	Acres Lost[b]	Average AUM[c] per Acre	Average AUM Lost per allotment
Southam	2,350	0.264	620
Wagon Hound	400	0.055	22
Total	2,750		642

(a) All numbers are approximate.
(b) Depending on the rate of revegetation of the processed shale, this will not represent a permanent loss.
(c) Current Bureau of Land Management Data.

Small Mammals. Nearly all individuals of the burrowing species will be permanently lost from disturbed areas; the larger nonburrowing species will be displaced during site preparation and during the deposition of processed shale within Southam Canyon. Although local losses will be substantial (between 30 to 35 percent of the on-tract populations), regional impacts may not even be measurable. The nearly total loss of rodents in the disturbed areas is not an irreversible, long-term loss. Almost all the species affected have a high reproductive potential and can recover from population losses of this magnitude in a few generations. In addition, rodents are expected to be among the first vertebrate groups to become reestablished on the vegetated processed shale pile and in revegetated disturbed areas. Species compositions are expected to change in the vegetation types due to differential responses of species to disturbance and habitat enhancement programs.

Indirect effects on mammals due to pollutants are unknown. If primary production by vegetation is adversely affected because of exposure to air emissions, mammal populations will probably also be affected.

5.4.2.4 Avifauna

Song Birds (Passeriformes). Bird populations will be affected through loss of breeding sites, cover, and food resources. The effective decrease in available on-tract bird habitat will be approximately 2,630 acres and will reduce the ground and shrub nesting population between 25 and 30 percent. Because birds are highly mobile, most individuals will leave the areas of activity. The effect of this loss of habitat to nonbreeding migrants such as darkeyed juncos and black and gray rosy finches will be minor; these species normally wander widely over the region and do not rely on small, fixed territories to assure a food supply.

Raptors. For the 20 raptor species known to use the area as wintering sites or as transients, the loss of habitat will affect available food resources. Since the shadscale habitat, which will be largely unaffected, produces the greatest rodent densities, raptor food resources lost in Southam Canyon and the process area may not have significant impacts on raptor numbers.

Golden eagles nest in Hell's Hole Canyon, Evacuation Creek Canyon, Southam Canyon, Asphalt Wash, and along the White River. One eagle nest in the disposal area in Southam Canyon is used every two to three years. Increased activity in Southam Canyon will eliminate this site during disposal; following work in the immediate area, it may be used again. None of the other eagle nest sites is expected to be affected directly.

Marsh hawks have nested in the eastern portion of the tracts and will not be affected by the proposed activities. American kestrels nest throughout the tracts; Southam Canyon has at least five nest sites that will be lost due to processed shale disposal activities. Once disposal is

complete and reclamation begins, the kestrels will probably return to these sites.

Prairie falcons nested within one kilometer of the process area in 1975. They have not returned to this nest site, but they did nest in the Evacuation Creek drainage in 1977. Since then, no nests have been located on the tracts, although prairie falcons are still sighted on occasion. Activities on tract will probably not affect this sporadic nesting activity.

Great horned owls nest along the White River and apparently in the juniper, although no nest sites have been found in the latter habitat. Since these raptors are the most numerous on the tracts, the loss of food resources will affect their number. Neither the process area nor the disposal area poses any threat to nest sites.

As with mammals, the effects of pollutants on birds are uncertain. Bird populations may be affected by air pollutant impacts on vegetation.

5.4.2.5 Reptiles

As is the case with other terrestrial groups, reptile populations will be lost as the vegetation is cleared or covered with processed shale. Since the disturbed areas account for about 25 percent of tract acreage, the local reduction of the reptile populations may be large; in absolute numbers, perhaps as much as 30 to 40 percent of the total number on the tracts. No regionally rare or unique species are found on tracts, however, and regional impacts will probably be negligible.

The effects of pollutants on reptiles are unknown. Consequently, it is not possible to predict the impacts of air and water pollution on these animals.

5.4.2.6 Terrestrial Invertebrates

Construction and operation of the project are not expected to measurably change the number or diversity of arthropod species in the region. Although the loss of upland habitats will at first diminish the arthropod populations on tract, the high reproductive potental of most arthropod species will enable them to recover very rapidly.

Changes in the vegetation composition will probably result in changes in invertebrate populations. Some species will be affected adversely; others will be affected favorably. There is the possibility of outbreaks of pest species, which could present problems to revegetation efforts. Changes in populations of insectivorous vertebrate species are also possible as a result of impacts on insects.

Pollutants in the environment may be taken up by invertebrates. If toxic compounds accumulated in this way, insectivorous animals could be affected. The extent of bioaccumulation on the tracts or regionally cannot be predicted at this time.

5.4.2.7 Aquatic Vertebrates and Invertebrates

Direct effects upon aquatic vertebrates and invertebrates through habitat alteration during construction and operation of the project will be small. Approximately one acre of riparian habitat will be used for construction of the well and pumping system. This should not affect aquatic populations adversely. Water intakes from the proposed White River Reservoir will be designed to prevent entrainment of fish, so that no significant direct impacts should occur to fish populations. Invertebrate populations should also be unaffected.

Indirect sources of project impacts include salts, metals, and hydrocarbons leached from processed and raw shale; fugitive dust; and deposition of particulates and other compounds in process emissions. Many of the

compounds contained in these pollutants exhibit toxic effects in high concentrations to fish and aquatic stages of other animals. Sublethal levels of many of these compounds produce more subtle effects than massive kills, such as altering egg and juvenile survival, disrupting chemical communication signals, creating morphological changes, and causing changes in important physiological processes.

At this time, it is not possible to determine how fish and amphibians will be affected. However, the potential for long-term adverse impacts is present. Monitoring sediment and water quality for suspected polluting agents and monitoring biota are the only ways to document and correct any long-term adverse impacts.

5.4.2.8 Aquatic Microorganisms

No direct effects are expected on the aquatic microbiological community (including the bacteria, fungi and algae) due to habitat alterations during the project. The dynamic nature of the river with its rapid bottom migration will tend to restore the substrate. The microorganisms have extremely high reproductive potential and mobility, and will recolonize disturbed areas rapidly.

The most important consideration for microbes is the indirect effects brought about by leaching, dust, and air emissions. Many of the potential compounds that enter the river can, through their presence in high concentrations, destroy large portions of the microbial populations. This is not expected to occur except in the event of a massive accidental spill or a rupture or overflow of any of the retention dams or process water holding ponds.

In sublethal concentrations (i.e., on the order of parts per billion in some cases), these compounds can produce several effects. Due to the difference in species specific resistance to pollutants, populations may shift towards more resistant species. Many of these organisms accumulate

toxins that may then be transmitted to nonadapted higher trophic levels, including man. Many of these compounds act as growth-stimulating agents in low concentrations but are toxic in high concentrations. This could result in higher productivity and nutrient cycling in the river system. However, sublethal levels of many of these compounds inhibit photosynthesis, growth, and overall production in algae. Many of the compounds, particularly some metals and hydrocarbons with low toxicity levels, exhibit toxic effects when several act synergistically. (Additional effects of changes in species assemblages are discussed in Section 5.4.3.)

5.4.2.9 Endangered or Threatened Species

Raptors. Two endangered raptors, the peregrine falcon (a predator of other birds), and the bald eagle have occurred on the tracts. No breeding sites for the falcon were located. Bald eagles were winter residents along the White River. No impacts are anticipated for either raptor due to project construction and operation.

Fish. The endangered Colorado River squawfish *(Ptychocheilus lucius)*, the humpback chub *(Gila cypha)*, and the very rare bony-tailed chub *(Gila elegans)* were not found on or within one mile of the tracts during the baseline data collection program and subsequent surveys. Squawfish in the White River have been found upstream and downstream from the tracts. The chubs are not expected to occur in the White River. Whether water withdrawal from the river will affect these fishes is unknown. However, they may be susceptible to spills or other sources of toxic materials from the site, should any such occur.

Invertebrates. The swallowtail species (*Papilio*), which may soon be placed on the endangered species list, is not expected to be significantly affected by the project. The carrot-like plants (*Umbelliferae*) on which its larvae subsist occur primarily in the shadscale habitat, which will be relatively undisturbed by project construction and operation.

Plants. No threatened or endangered plants were found on the tracts by Arthur Holmgren, curator of the Intermountain Herbarium in Logan, Utah.

5.4.3 CHANGES IN ECOSYSTEM STRUCTURE AND FUNCTION

In addition to affecting particular groups of organisms, the project will affect ecosystem structure and function. In the following sections, ecosystem relationships that will probably be altered by oil shale development are discussed.

5.4.3.1 Terrestrial Subsystem

The terrestrial subsystem will undergo changes in internal structure and function and in relationships with White River as well as with off-tract systems. Although change is inevitable, the purpose of the environmental protection procedures is to minimize these changes.

Internal changes will be caused primarily by habitat removal and enchancement, and by human activities associated with the development. These impacts will cause changes in the abundance and diversity of the biota. Initially, productivity will decrease, but with proper management, productivity can recover. The extent of recovery will depend on the revegetation and habitat improvement programs.

The effects of increased atmospheric pollutant inputs are not known, but are expected to be small. However, some general types of changes seem likely. Species diversity and abundance of the biota will change. The nature of these changes is not predictable at this time, but data gathered in the monitoring program will help to define them. Ecosystem productivity will likely be changed because of pollutants. Again the nature of these changes is unknown, and the changes are likely to be manifested via altered vegetation and microbial processes. Primary production will be affected positively in some species and negatively in others. Important microbial functions such as nitrogen fixation, nutrient cycling, and

mycorrhizal associations will be affected. The extent of these changes and their results in terms of ecosystem processes are unknown at this time.

The White River system will probably be affected by the following:

- Altered transport of organic material to the river (quantity and composition)
- Altered nutrient pulses during construction, prior to successful revegetation
- Possible export to the river of polluting compounds and trace elements via the atmosphere and water systems

Effects on neighboring terrestrial ecosystems may occur as a result of the following on-tract disturbances:

- Atmospheric pollutants
- Displaced wildlife
- Contaminated water
- Increased human activity

5.4.3.2 Aquatic Subsystem

Direct impacts are not expected in structure or function of the White River and White River Reservoir subsystems due to the construction and development of the oil shale project. These subsystems will undergo possible structural and functional changes due to disturbances of the terrestrial subsystem. These disturbances are described in the previous section and include altered nutrients and organic and toxic compounds. As discussed previously, many of these will result in direct toxic effects upon organisms if present in high concentrations.

Altered rates of nutrient cycling and primary production by bacteria, fungi, and algae, coupled with altered patterns of organic input from the terrestrial system, can affect the amount and composition of food available to

the higher organisms, invertebrates, and fish. This can change the population dynamics of species in higher trophic levels. Long-term changes in the character of the aquatic subsystem could result. The direction and extent of these changes cannot be predicted at this time. The monitoring program for project-related substances and ecosystem structure and function in both the aquatic and terrestrial subsystems is the most effective means of finding and correcting potential adverse impacts.

5.4.4 EFFECTS OF THE WHITE RIVER RESERVOIR

The preferred water source for the commercial operation phases of the White River Shale Project is the White River Reservoir, proposed by the state of Utah. The water supply alternative study for the shale project, prepared by Bingham Engineering, has been submitted as an accompanying document to the DDP. The White River Reservoir Project, however, is independent of the White River Shale Project; evaluation of the environmental effects of the reservoir is the responsibility of the reservoir project sponsor and is not presented here.

Although almost all of this reservoir will be located off tract, it will have some impact on on-tract terrestrial and aquatic habitat. Much of the riparian habitat (approximately 150 acres) and all of the existing riverine habitat found on the tracts will disappear as a result of the proposed dam. Within the tracts, changes in the biological baseline that can be expected to occur because of inundation can be important in the analysis of impacts from the commercial phases.

The withdrawal of water to supply the White River Shale Project will have some effect on conditions in the new reservoir. An evaluation of the modified baseline conditions after the reservoir process has been completed.

The populations supported by the riparian habitat will be displaced to upstream and downstream riparian areas or to surrounding sagebrush-greasewood and shadscale habitats, which are markedly different from the riparian. It is also possible that the populations in this habitat may be destroyed.

5.5 EFFECTS ON SOILS AND GEOLOGY

The White River Shale Project will alter the topography of Tracts Ua and Ub, particularly in Southam Canyon. Mining operations will also remove a major part of the oil-rich Mahogany zone that underlies the area. This section presents findings based on studies of soils and geology that were initiated to determine both existing conditions at the site and the probable effects of construction and operation of the project.

5.5.1 PHASE I

Construction during Phase I will affect the soil management, topography, and minerals of Tracts Ua and Ub to varying degrees, as described in the following paragraphs.

5.5.1.1 Construction Effects

Soil Productivity. The soils on Tracts Ua and Ub are generally coarse and contain long thin sandstone fragments, as shown in Table 5.5-1. Situated in an arid environment, these soils are moderately alkaline, generally shallow, have low water-holding capacity, and are not suited for row crops. However, they support desert vegetation, wildlife, and in the winter, sheep. Bureau of Land Management records show that the Southam Canyon allotment currently supports approximately one sheep on 34 acres, which is equivalent to 170 acres per Animal Unit Month (AUM).

With so little land (approximately 300 acres) being preempted by construction and operation in Phase I, the regional effect on soil productivity should be minimal.

Soil Erosion. Some erosion of soil is anticipated during construction. Soils in these areas are rated moderate to severe in erodibility (Table 5.5-1). Drainage structures, however, will minimize long-term effects of erosion. Tank farms and other fire-sensitive areas will not be revegetated, but may be chemically treated for soil stabilization.

Table 5.5-1

CHARACTERISTICS OF SOILS
AFFECTED BY OIL SHALE
DEVELOPMENT

Mapping Unit		Soil Type	Dominant	ater(b) olding apacity nches	Vegetation
1.	As5	AsC-Unita sandstone complex	Channery loam	1	Mainly sagebrush and shadscale
2.	A3	AC-BD complex	Channery	1-2	Shadscale, black sage, rabbitbrush needlegrass
3.	FR	F-loams sand Unita complex	Loamy sa	0.6-1	Spring hopsage, rabbitbrush, black sagebrush
4.	ND	ND-DsB complex	Fine san	6-8	Greasewood, shadscale, hopsage, and annual weeds
5.	D	D-sandy loam	Sandy lo	7-8	Sagebrush, greasewood, fourwing saltbrush, rabbitbrush
6.	Asl	AsC-BsC complex	Channery loam	1	Mainly sagebrush and shadscale
7.	Bs5	BsC-Unita sand-stone complex	Channery loam	0.5	Juniper, black sagebrush, shad-scale, rabbitbrush
8.	Bs5	Same as 7			
9.	D	Same as 5			
10.	AsL	Same as 6			
11.	R	Unita sandstone-BsE complex	Massive s	N/A	None
12.	Bs3	Bs3-Units sandstone complex	Very chan very flag sandy loa	0.5	Juniper, black sagebrush, shad-scale, blue bunch wheatgrass
13.	A2	A-channery loam	Channery	1-2	Shadscale, blacksage, rabbitbrush, needlegrass

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CHARACTERISTICS OF SOILS AFFECTED BY OIL SHALE DEVELOPMENT

Mapping Unit	Soil Type	Dominant Texture	Soil Depth (inches)	Erosion Hazard	Present Use	Slope (%)	pH Range[a]	Permeability	Runoff	Water[b] Holding Capacity Inches	Vegetation
ACCESS ROAD											
1. As5	AsC-Unita sandstone complex	Channery[c] sandy loam	12-19.5	Moderate	Winter sheep grazing, wildlife habitat	10-20	8.0-8.9	Moderate	Medium	1	Mainly sagebrush and shadscale
2. A3	AC-BD complex	Channery loam	12-19.5	Moderate	Winter sheep grazing, wildlife habitat	10-40	8.0-8.7	Moderate	Medium to low	1-2	Shadscale, black sage, rabbitbrush needlegrass
3. FR	F-loams sand Unita complex	Loamy sand	4-15.5	Moderate-severe	Winter sheep grazing, wildlife habitat	3-7	8.1-8.5	Moderate to rapid	Medium to high	0.6-1	Spring hopsage, rabbitbrush, black sagebrush
4. ND	ND-DsB complex	Fine sandy loam	50-60	Moderate	Winter sheep grazing, wildlife habitat	5-10	8.7-8.3	Low	Moderate to rapid	6-8	Greasewood, shadscale, hopsage, and annual weeds
5. D	D-sandy loam	Sandy loam	60	Moderate	Winter sheep grazing, wildlife habitat	5-10	8.0-8.2	Moderate	Medium	7-8	Sagebrush, greasewood, fourwing saltbrush, rabbitbrush
6. Asl	AsC-BsC complex	Channery sandy loam	12-19.5	Moderate	Winter sheep grazing, wildlife habitat	10-20	8.0-8.9	Moderate	Medium	1	Mainly sagebrush and shadscale
7. Bs5	BsC-Unita sand-stone complex	Channery sandy loam	2-10	Moderate-severe	Wildlife and limited sheep grazing	10-20	8.2-8.4	Moderate	Medium to high	0.5	Juniper, black sagebrush, shad-scale, rabbitbrush
PROCESS AREA											
8. Bs5	Same as 7										
9. D	Same as 5										
10. AsL	Same as 6										
11. R	Unita sandstone-BsE complex	Massive sandstone	N/A	N/A	None	40-70	N/A	N/A	Rapid	N/A	None
12. Bs3	Bs3-Units sandstone complex	Very channery and very flaggy[d] sandy loam	2-10	Moderate-severe	Wildlife habitat and limited winter sheep grazing	40-60	8.2-8.4	Moderate	Medium to high	0.5	Juniper, black sagebrush, shad-scale, blue bunch wheatgrass
13. A2	A-channery loam	Channery loam	12-20	Moderate	Winter sheep grazing, wildlife habitat	10-20	8.0-8.7	Moderate	Medium to low	1-2	Shadscale, blacksage, rabbitbrush, needlegrass

Mapping Unit	Soil Type	Dominant Texture	Soil Depth (inches)	Erosion Hazard	Present Use	Slope (%)	pH Range[a]	Permeability	Runoff	Water[b] Holding Capacity (inches)	Vegetation
					PROCESSED SHALE DISPOSAL AREA						
14. Bs3	Same as 12										
15. D	Same as 5										
16. Bs4	BS-channery sandy loam	Channery sandy loam	2-10	Moderate-severe	Wildlife habitat and limited winter sheep grazing	10-20	8.2-8.4	Moderate	Medium to high	0.5	Juniper, black sagebrush, shad-scale, blue bunch wheatgrass
17. A2	Same as 13										
18. As1	Same as 10										
19. R	Same as 11										
20. Bs1	BsD-Unita sand-stone complex	Channery and flaggy sandy loam	2-10	Moderate-severe	Wildlife habitat and limited winter sheep grazing	20-40	8.2-8.4	Moderate	Medium to high	0.5	Juniper, black sagebrush, shad-scale, blue bunch wheatgrass
					PIPELINE CORRIDOR						
21. A4	AB-BD complex	Channery loam	12-20	Moderate	Wildlife habitat, limited winter sheep grazing	20-40	8.2-8.4	Moderate	Medium to low	1-2	Shadscale, blacksage, rabbitbrush, needlegrass
22. FR	Same as 3										
23. R	Same as 11										
24. Bs3	Same as 12										
25. Bs5	Same as 7										
26. D	Same as 5										

(a) First figure denotes the pH of the topsoil; the second figure, the pH of the soil just above bedrock.
(b) The moisture data relate to the entire soil depth.
(c) A channery soil is one that contains thin, flat sandstone fragments up to 6 inches along the longer axis.
(d) A flaggy soil is one that has relatively thin sandstone fragments from 6 to 15 inches long.

Topography. Site preparation for Phase I will require grading and leveling of approximately 55 acres. In addition, another 55 acres will be needed to develop facilities such as pipelines and roads. Other construction activities, such as diversion ditches, small retention dams, and power corridors, will result in minor changes to topography, for a total affected area of approximately 300 acres.

Subsurface Zones. Subsurface operation during Phase I will necessitate sinking three vertical access shafts to the oil shale. Because a small amount of material will be extracted by construction of these shafts, the effects should be negligible, and the mined material (sandstone, siltstone, marlstone, and kerogen-rich marlstone or oil shale) will be deposited in a small side canyon within Southam Canyon or used in the construction of drainage facilities.

Mineral Resources. Construction should have no effect on mineral resources.

5.5.1.2 Operation Effects

Soil Productivity. The processed shale from Phase I will cover an area of approximately 130 acres. This should have a negligible effect on soil productivity for the entire region.

Soil Erosion. Up to 20,025 TPSD of processed shale will be deposited near the east rim of Southam Canyon. As described in Section 3.10, wind and rain are anticipated to cause some minor erosion of the processed shale pile before revegetation is completed. A 5-percent slope will be maintained to reduce erosion as the fill material is placed. At the end of the operation, the top surface of the processed shale pile will reach an average elevation of 5,850 feet. The pile surface will be contoured to reduce erosion, as described in Section 4.6.

Topography. The major topographic alteration will result from the processed shale pile in Southam Canyon.

Subsurface Zones. A two-bench room-and-pillar mining system is expected to yield about 65 percent of a defined mining interval, as described in Section 3.5. As a result of the removal of minable oil shale from the Mahogany Zone and the placement of processed shale on the surface, stresses within the geological zone may occur (see Section 4.5).

Mineral Resources. Effects on existing mineral resources, excluding oil shale, are expected to be negligible.

5.5.1.3 Effects Off Tract

The entire mining operation will be conducted within Tracts Ua and Ub. However, power corridors, access roads, and other offsite activities will affect topography. These effects are not expected to be appreciable.

5.5.2 PHASES II AND III

5.5.2.1 Construction Effects

Soil Productivity. Since there is low soil productivity on the lease property, and since construction for Phases II and III will cover approximately 300 acres, excluding processed shale disposal, the effects should be minimal.

Soil Erosion. With the implementation of the soil erosion control plan described in Section 4.5, soil erosion from construction should be kept to a minimum. The effects of such construction are similar to those described for Phase I.

Topography. A permanent retention dam will be built for Phases II and III in Southam Canyon to contain the contaminated runoff from the processed shale. Other topographical changes caused by construction should be similar to those described for Phase I. Expansion of the process area and other facilities, such as construction of the freshwater impoundment, will modify the topography of Tract Ua.

Subsurface Zones. The effects produced by construction on the subsurface, though greater in scope, follow the same pattern as those described for Phase I.

Mineral Resources. Construction will have no appreciable effects on existing mineral resources.

5.5.1.2 Operation Effects

Soil Productivity. It is estimated that after 20 years of Phases II and III, approximately 3.5 square miles of Southam Canyon will have been filled. Revegetation will return at least equal productivity to the land.

Soil Erosion. Topsoil classified as D soils (Table 5.5-1) will be placed in trenches in the processed shale deposit to be used for revegetation, as described for Phase I. Limited erosion will take place between the beginning of processed shale disposal and the completion of revegetation. Implementation of an erosion control plan will reduce the erosion potential.

Topography. Disposal of the processed shale will greatly change the topography by covering approximately 3.5 square miles of Southam Canyon to an average thickness of 212 feet. Final grading will produce a 4:1 (horizontal to vertical) slope on the face of the shale pile with alternating gentle hills and depressions to collect water during periods of rainfall. By the end of Phases II and III, the mean elevation of the hills will be 5,800 feet sloping gently to the north.

Subsurface Zones. During Phase II approximately 95,700 TPSD of shale will be mined for processing. Phase III will see the production rate doubled and maintained for the life of the project, until the Mahogany Zone has been substantially mined out of Tracts Ua and Ub. The mine will be designed to minimize surface subsidence. However, stress changes will occur in the geological formation, as a result of the removal of the oil shale zone and the placement of processed shale on the surface.

Mineral Resources. The effects produced on existing mineral resources, excluding oil shale and water, are predicted to be negligible. Sulfur will be produced as a minor byproduct of the process. Recovery of profitable minerals located near the surface will be difficult in areas where processed shale has been deposited. However, studies indicate that such minerals are probably not present on Tracts Ua and Ub. Deep-lying resources such as oil and gas may still be recoverable on the lease land.

5.5.2.3 Effects Off Tract

During Phases II and III, off-tract effects related to soils and geology are expected to be negligible, since the mining operation and production activities will be confined mainly to the lease land.

5.6 EFFECTS ON HISTORIC, PREHISTORIC, AND PALEONTOLOGICAL RESOURCES

The White River Shale Project will affect the historic, archeologic, and paleontological resources of Tracts Ua and Ub. Possible adverse effects include partial or complete destruction of sites by construction and operation activities. Because of existing poor surface conditions, subsurface testing is necessary at one on-tract site to determine its significance. The project will also have the indirect effect of exposing a previously undeveloped area to public vandalism. To prevent such actions now, no maps or specific location data are included in this report.

5.6.1 PHASE I

Construction of Phase I will have little impact on historic, prehistoric, and paleontological resources on the site. In the following paragraphs, the resources are described and the effects evaluated.

5.6.1.1 Construction Effects

Historic Resources. The only historic structure on the site is an early 20th century cabin on the northwest corner of Section 14. It has no historical or aesthetic value and, in any case, will not be affected directly by Phase I activities or subsequent construction.

Prehistoric Resources. There are historic components in some of the archeological sites. The pipeline that will be built from the White River to the water storage tank will pass through Site 372. Collection of surface finds, location recording, and site analysis have already been performed, and no further investigation of this site is recommended.

Six other archeological sites located on tract are unlikely to be directly or indirectly disturbed by any Phase I activity. Those sites adjacent to

access roads (409, 408, and 324), however, may be exposed to possible vandalism by virtue of visibility. Since no further study is recommended for Sites 408 and 324, any impact on them would not require mitigation. The potholes in Site 409, a rock shelter, indicate considerable depth of deposit. Test excavation of Site 409 is recommended to determine its significance and to plan mitigation efforts, if found to be necessary.

Site 324, which may be disturbed by widening the access road, and an open site, Site 406, have not been recommended for any further work because they apparently lack subsurface features. Site 373 will be directly affected by the state dam project construction and will be assessed in the EIS prepared for that project; therefore, an evaluation of possible indirect impacts of the White River Shale Project on this site is not necessary.

Paleontological Resources. In general, the oil shale development will not directly affect significant fossil sites, but two minor paleontological sites will be disturbed by Phase I construction. Site 6, containing unidentifiable fossilized plant debris, is located partially within the proposed water pipeline right-of-way but has been analyzed as insignificant. Site 32, which contains unidentifiable bone fragments of minor significance, may be directly affected by earth-moving activity in the process area.

Site 36, containing insignificant petrified wood from the Uinta Formation, lies in the shale process area and will thus be directly affected by construction of the plant. Site 4, an insignificant site containing unidentifiable plant debris, may be disturbed by widening the access road.

5.6.1.2 Operation Effects

Phase I operation will place no stress on any historic, prehistoric, or paleontological resource on Tracts Ua and Ub.

5.6.2 PHASE II

Phase II construction and operation will have no further impact on historic and prehistoric resources beyond those already identified. Paleontological matter in Site 29, petrified wood from the Uinta Formation, will be directly affected in Phase II operation by disposal of processed shale in Southam Canyon. These fossils are considered of minor significance, and, thus, the impact will be minimal.

5.6.3 PHASE III

Phase III construction and operation will have no further impact on historic and prehistoric resources on Tracts Ua and Ub.

The majority of the remaining paleontological sites (Sites 1, 23, 28, 30, and 35) located on Tract Ua will be directly affected by the processed shale disposal. For the most part, the fossils are plant and wood specimens of minor importance. Brontothere fossils found in Site 28 need to be removed to avoid loss during later processed shale disposal activities.

5.6.4 OFF-TRACT IMPACTS

Little or no direct impact will occur in regard to the off-tract sites found during the Baseline survey. The following paragraphs discuss the status of the three types of sites identified.

5.6.4.1 Historic Resources

Within one mile of the tracts, there are three additional early 20th century cabins in a state of general disrepair. Since they are considered historically insignificant as a group, they are not evaluated in terms of possible project impact. The only site of historical significance in the immediate area is the Ignacio Stage Stop, located east of State Highway 45.

5.6.4.2 Prehistoric Resources

Approximately 15 of the sites located along the terraces of the White River will be inundated by the proposed state dam project and will be the state's responsibility. Sites 401, 118, 368, 369, and 372 may also be affected by the rising pool level caused by the dam. Most of the remaining sites are surface scatters of cultural detritus which were recorded and collected during the surface reconnaissance; any direct impacts to these sites will be insignificant.

5.6.4.3 Paleontological Resources

The majority of significant paleontological sites discovered during the survey are located off tract. Brontothere fossils of major significance from the Uinta Formation have been found north of the White River. The fossils are abundant and in good condition and are found ranging through a few hundred feet of strata, which makes them particularly valuable for evolutionary studies. In addition, since previous work on them is incomplete, they are scientifically important for future studies.

Important insect fossil sites have been located adjacent to Tract Ub. None of these, however, will be directly affected by the project.

5.7 EFFECTS ON AESTHETICS

5.7.1 INTRODUCTION

Aesthetic impacts result from changes in the form, line, color, and texture of the characteristic landscape. These changes are perceived differently, depending on individual reactions to sight, smell, touch, and taste. In project development, one of the design criteria should be to complement rather than deviate from the characteristic landscape.

5.7.2 THE REGIONAL AESTHETIC SETTING

Aesthetic impacts to the three landscape units defined in Section 2.7 are discussed in terms of full-capacity processing (Phase III). Figure 5.7-1 shows the proposed facilities superimposed on the landscape units. The major project components that will affect the aesthetics are the process facilities, the tank farm, the process shale disposal, the transport systems, the raw shale stockpile, and the onsite reservoirs.

Aesthetic impacts for each landscape unit are summarized in Tables 5.7-1 through 5.7-3 and are rated according to the following system of evaluation:

+ <u>Positive</u>. Enhancement of the scenic quality of the area, additional diversity to the natural landscape, and increase in the field of vision of the foreground and middleground.

o <u>No Significant Change</u>

\- <u>Negative</u>. Loss of diversity in the natural landscape and decrease in the field of the foreground and middleground; loss of natural color and contour compatibility.

N/A <u>Not Applicable</u>. Change will not occur in the landscape unit being considered.

Impacts to the aesthetic resources will be somewhat reduced by the topography of the site, which offers a natural screening for man-made modifications. Many of the facilities will be contained within local view sheds, which will restrict long-range visibility.

5.7.3 THE RIDGETOP-BASIN LANDSCAPE UNIT

Table 5.7-1 shows the extent of impact to the ridgetop-basin unit. As shown, most of the project facilities will be located within the ridgetop-basin unit. The major project components affecting the ridgetop-basin complex will be the 15 retorts, the 12 tanks in the tank farm, the processed shale disposal area, the transport system, the raw shale stockpile, and the onsite impoundments.

The process facilities will visually interrupt the strongly horizontal line surfaces of the existing ridgetops. On any of the ridges adjacent to the plant site, the process facilities will provide an acute contrast to the surrounding ridgetop-basin landscape. The smooth texture of the facilities will be incompatible with the coarsely textured rock forms, vegetation, tree cover, and knolls. Painting these facilities pastel and muted natural colors will reduce this visual impact to some extent; however, in this area the plant will remain a dominant form. Since the retorts and upgrading facilities will be contained mostly within a basin, they will be screened from distant view by the many intervening ridges.

The tank farm layout will complement the characteristic land form. The cylindrical tanks will be screened by the rounded and massively blocked landscape setting and will be painted natural colors to complement the landscape.

The process shale disposal site will be one of the major impacts on the ridgetop-basin complex. Processed shale will be deposited in Southam Canyon; the shale pile surface will be contoured to a hilly, natural appearance, and the pile will reduce a portion of the panoramic views in

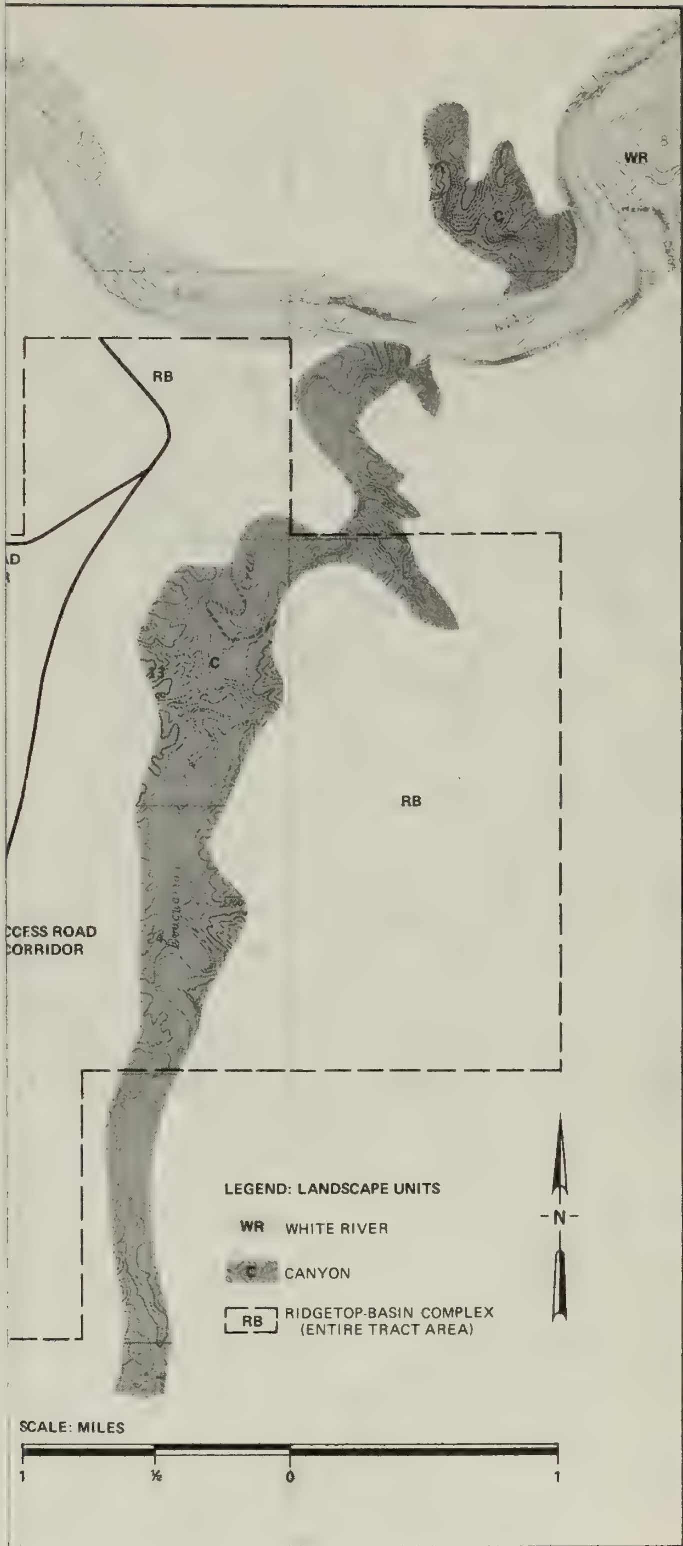

Figure 5.7-1 LANDSCAPE UNITS FOR EVALUATING AESTHETIC RESOURCES

Impacts to the aesthetic resources will be somewhat reduced by the topography of the site, which offers a natural screening for man-made modifications. Many of the facilities will be contained within local view sheds, which will restrict long-range visibility.

5.7.3 THE RIDGETOP-BASIN LANDSCAPE UNIT

Table 5.7-1 shows the extent of impact to the ridgetop-basin unit. As shown, most of the project facilities will be located within the ridgetop-basin unit. The major project components affecting the ridgetop-basin complex will be the 15 retorts, the 12 tanks in the tank farm, the processed shale disposal area, the transport system, the raw shale stockpile, and the onsite impoundments.

The process facilities will visually interrupt the strongly horizontal line surfaces of the existing ridgetops. On any of the ridges adjacent to the plant site, the process facilities will provide an acute contrast to the surrounding ridgetop-basin landscape. The smooth texture of the facilities will be incompatible with the coarsely textured rock forms, vegetation, tree cover, and knolls. Painting these facilities pastel and muted natural colors will reduce this visual impact to some extent; however, in this area the plant will remain a dominant form. Since the retorts and upgrading facilities will be contained mostly within a basin, they will be screened from distant view by the many intervening ridges.

The tank farm layout will complement the characteristic land form. The cylindrical tanks will be screened by the rounded and massively blocked landscape setting and will be painted natural colors to complement the landscape.

The process shale disposal site will be one of the major impacts on the ridgetop-basin complex. Processed shale will be deposited in Southam Canyon; the shale pile surface will be contoured to a hilly, natural appearance, and the pile will reduce a portion of the panoramic views in

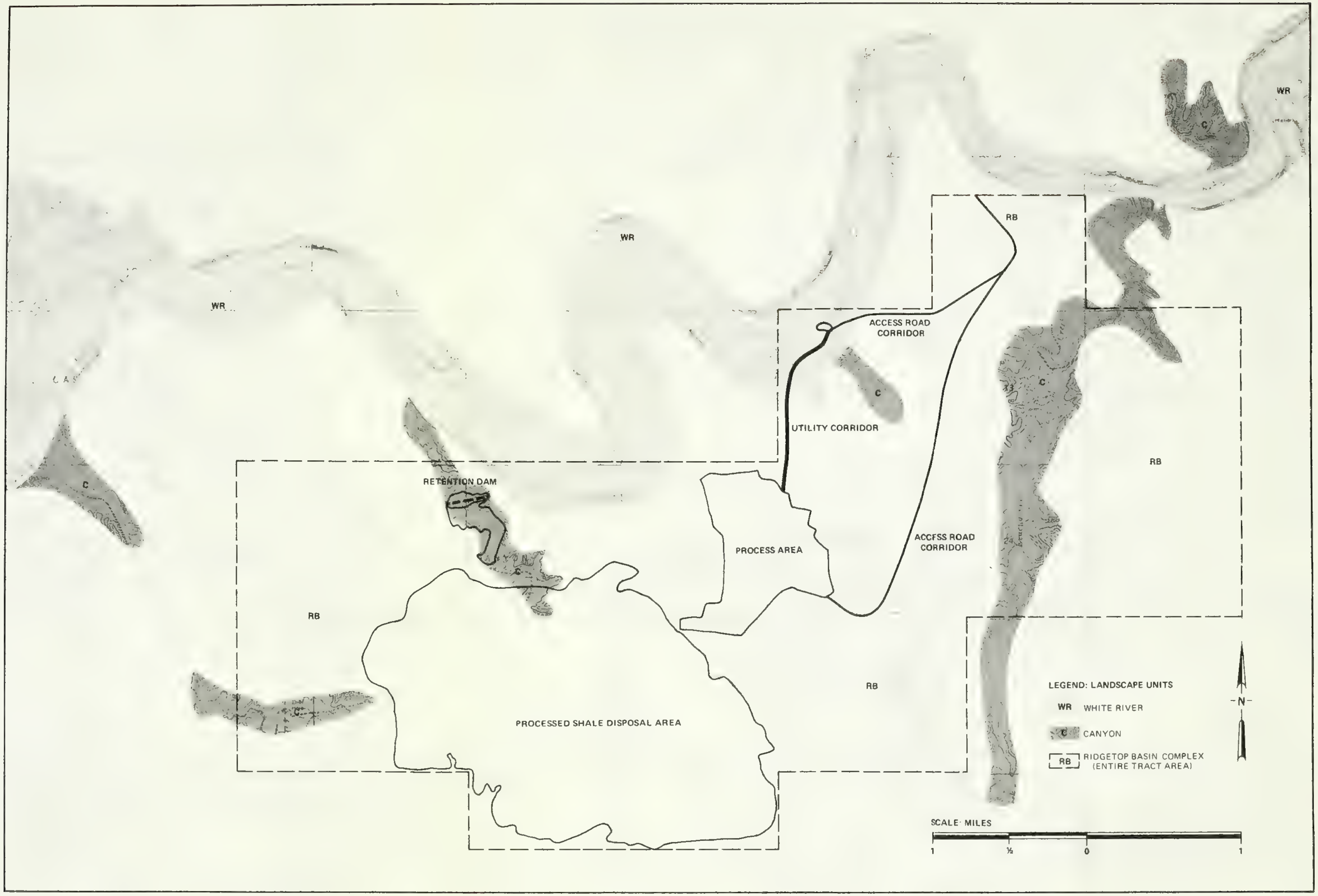

Figure 5.7-1 LANDSCAPE UNITS FOR EVALUATING AESTHETIC RESOURCES

Table 5.7-1

AESTHETIC IMPACTS: RIDGETOP-BASIN LANDSCAPE UNIT

Type of Impact	Phase I			Phase II			Phase III		
	Construction	Operation	Decommissioning	Construction	Operation	Decommissioning	Construction	Operation	Decommissioning/ Abandonment
Land									
Geologic surface material[a]	o	o	o	—	—	o	—	—	o
Topographic characteristics (relief)	o	o	o	—	—	—	—	—	o
Air									
Visual and olfactory	o	o	o	o	o	o	—	—	+
Noise	o	o	o	o	o	o	—	—	+
Water									
Appearance	N/A	N/A	N/A	N/A	+	o	N/A	+	o
Land-water interface	N/A	N/A	N/A	N/A	+	o	N/A	+	o
Odor and floating material	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Water surface area	N/A	N/A	N/A	N/A	+	o	N/A	+	o
Wooded and geologic shoreline	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Biota									
Domestic animals	o	o	o	—	—	o	—	—	+
Wildlife	o	o	o	—	—	o	—	—	+
Diversity of vegetation	o	o	o	o	—	o	o	—	+
Variation within vegetation types	o	o	o	o	—	o	o	—	+
Man-Made Objects[a]									
Plant facilities	—	—	o	—	—	o	—	—	o
Ancillary facilities	o	o	o	o	o	o	o	o	o
Corridor selection	—	—	o	—	—	o	N/A	—	o
Processed shale disposal	N/A	—	o	N/A	—	o	N/A	—	o

(a) Visual impacts to users of landscape units.

Legend: + Positive impact
o No impact
— Negative impact
N/A Not applicable

Southam Canyon. Additional impacts will result from fugitive dust associated with processed shale disposal. The choice of Southam Canyon as the disposal area will reduce the exposure of the waste-material pile within the existing landscape setting.

Construction of access roads, pipeline corridors, and conveyor systems will produce changes over much of the tracts. The access roads will be visible from the ridgetops, even after the decommissioning stage. Construction of these roads will create noise and dust; the construction of the pipelines will have impacts on visual and air quality and will create noise in the area. These impacts will be short-term, since pipeline construction progresses at a rate of approximately 1/2 to 1 mile per day. After construction of the pipeline, a revegetation program will be initiated to reduce any visual residual scar of the utility corridor. Because the transmission lines will use the same utility corridors as the pipelines, land disturbance will be kept to a minimum; however, transmission towers along these corridors will detract from the natural setting.

The conveyors will also detract from the natural setting, although they will be painted muted colors to blend with the existing environment. Certain stretches will be elevated 10 to 30 feet aboveground. Sounds emitted by this system will add to the deterioration of the normal tranquility of this wilderness setting.

The primary crushed shale stockpile will be over 100 feet high, covering approximately 10 acres, and will be situated against a ridge that ranges in height from approximately 50 to 70 feet. The stockpile will be easily visible from some of the ridges in the plant area and will detract from the natural form, line, and texture of the existing environment. Its color will not detract significantly from the background.

Construction of the impoundments will cause dust, noise, and visual impacts on the immediate process area; however, when these impoundments are filled with water, they will introduce diversity into the landscape unit. After decommissioning of the operations, the water in these impoundsments will evaporate. Vegetation in these areas will eventually reestablish naturally.

5.7.4 THE CANYON LANDSCAPE UNIT

Construction and subsequent use of the Southam Canyon retention dam and the processed shale pile will affect the canyon landscape unit. The extent of the effects is summarized in Table 5.7-2.

The impoundment structure will differ from the characteristic landscape by its artificial appearance. The processed shale pile in Southam Canyon will destroy a portion of the views that are characteristic of this landscape unit.

5.7.5 THE WHITE RIVER LANDSCAPE UNIT

Impacts on the White River landscape unit will result primarily from construction of the pipeline corridors and pump station on the White River. The extent of these impacts is summarized in Table 5.7-3. The pump station will have a visual impact only during construction; afterwards it will be painted a neutral color consistent with the natural colors of the landscape unit.

Recreational users of the White River and the state reservoir will have an unobstructed view of the processed shale disposal site. During construction of the processed shale pile, the visual impact of its deviation from the characteristic landscape will be increased by fugitive dust.

Table 5.7-2

AESTHETIC IMPACTS: CANYON LANDSCAPE UNIT

Type of Impact	Phase I			Phase II			Phase III		
	Construction	Operation	Decommissioning	Construction	Operation	Decommissioning	Construction	Operation	Decommissioning/ Abandonment
Land									
Geologic surface material (a)	N/A	N/A	N/A	—	—	—	o	—	—
Topographic characteristics (relief)	N/A	N/A	N/A	—	—	—	o	—	—
Air									
Visual and olfactory	N/A	N/A	N/A	—	—	o	o	—	+
Noise	N/A	N/A	N/A	—	—	o	o	—	+
Water									
Appearance	N/A	N/A	N/A	N/A	—	—	N/A	—	—
Land-water interface	N/A	N/A	N/A	N/A	—	—	N/A	—	—
Odor and floating material	N/A	N/A	N/A	N/A	—	—	N/A	—	—
Water surface area	N/A	N/A	N/A	N/A	—	—	N/A	—	—
Wooded and geologic shoreline	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Biota									
Domestic animals	N/A	N/A	N/A	—	—	o	N/A	—	+
Wildlife	N/A	N/A	N/A	—	—	o	N/A	—	+
Diversity of vegetation	N/A	N/A	N/A	—	—	o	N/A	—	+
Variation within vegetation types	N/A	N/A	N/A	—	—	o	N/A	—	+
Man-Made Objects (a)									
Plant facilities	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ancillary facilities	N/A	N/A	N/A	—	—	o	—	—	o
Corridor selection	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Processed shale disposal	N/A	N/A	N/A	N/A	—	N/A	—	—	—

(a) Visual impacts to users of landscape units.

Legend:
+ Positive impact
o No impact
— Negative impact
N/A Not applicable

Table 5.7-3

AESTHETIC IMPACTS: WHITE RIVER LANDSCAPE UNIT

Type of Impact	Phase I			Phase II			Phase III		
	Construction	Operation	Decommissioning	Construction	Operation	Decommissioning	Construction	Operation	Decommissioning/ Abandonment
Land									
Geologic surface material[a]	—	—	o	—	—	o	N/A	—	o
Topographic characteristics (relief)	—	—	o	—	—	o	—	—	+
Air									
Visual and olfactory	—	—	o	—	—	o	—	—	+
Noise	o	o	o	o	o	o	o	o	o
Water									
Appearance	—	o	o	—	o	o	o	o	—
Land-water interface	—	—	o	—	—	—	N/A	—	+
Odor and floating material	o	o	o	o	o	o	o	o	o
Water surface area	o	o	o	o	o	o	o	o	o
Wooded and geologic shoreline	—	o	o	—	o	o	o	o	+
Biota									
Domestic animals	—	—	o	—	—	—	—	—	+
Wildlife	—	—	o	—	—	—	—	—	+
Diversity of vegetation	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Variation within vegetation types	—	—	o	—	—	o	—	—	+
Man-Made Objects[a]									
Plant facilities	—	—	o	—	—	o	—	—	+
Ancillary facilities	—	—	o	—	—	o	N/A	N/A	+
Corridor selection	—	—	o	—	—	o	N/A	N/A	+
Processed shale disposal	N/A	—	o	N/A	—	+	N/A	—	+

(a) Visual impacts to users of landscape units.

Legend: + Positive impact
o No impact
— Negative impact
N/A Not applicable

5.7.6 SUMMARY

The majority of intrusive visual, olfactory, and noise factors associated with the White River Shale Project are localized within the ridgetop-basin and canyon units. Many of the facilities and land modification of the White River Shale Project will be seen only from on-tract access roads, from vantage points on the adjacent ridges, or from the air. The natural topography of the landscape units is well suited to absorb, or locally contain and subordinate, the alterations to the land to be caused by the project. The White River Canyon, which is the most recreationally used unit, will be affected by only one major project component — the processed shale pile. The pump station will be visible along the White River.

5.8 ENVIRONMENTAL EFFECTS OF DECOMISSIONING-ABANDONMENT

Plans for decommissioning or abandonment of White River Shale Project facilities are discussed in Section 3.21. Decommissioning refers to suspension of work programs without dismantling or destruction of improvements. Abandonment refers to relinquishment or termination of the lease and disposition of improvements.

5.8.1 DECOMMISSIONING

5.8.1.1 Decommissioning of Mine

In decommissioning, mine equipment will be mothballed and stored. Mine structures will be inspected periodically and maintained. Consequently, the facility will be available for the resumption of operations when needed.

Pumping of the mine will be continued as required to control water. The water from the mine will be discharged to the stormwater holding basin.

5.8.1.2 Decommissioning of Aboveground Facilities

In decommissioning, aboveground facilities used during Phase I operations will be maintained for future use. Chemicals will be either stored or disposed of in an approved disposal area. Treatment of surface runoff will continue, if necessary, to prevent development of a standing pond of objectionable water in the catchment basin. If hazardous wastes are disposed of on tract, post-construction monitoring will be conducted in accordance with RCRA. Existing revegetated areas will be maintained.

5.8.2 ABANDONMENT

5.8.2.1 Abandonment of Mine

If the mine is abandoned after the presently leased resource is exhausted, economically salvageable equipment will be removed. The mine shafts and portals will be sealed to remove the hazards to man and animals.

5.8.2.2 Abandonment of Aboveground Facilities

In abandonment, economically salvageable equipment and materials will be removed. Surface structures will be taken down to grade. The land will not be returned to its original contours, but disturbed areas will be rehabilitated to bring them to a usable and productive condition in compliance with lease requirements.

Safe access to permanent impoundments will be provided for wildlife, livestock, and man. If consumption of some impounded waters would be detrimental to man or animal, access will be prevented by construction of permanent barriers.

Revegetation of the processed shale disposal area and maintenance of revegetated areas will be continued for a reasonable period of time.

REFERENCES — SECTION 5

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5-4 M. W. Chan, S. J. Head, and S. Machiraju, "Development and Validation of an Air Pollution Model for Complex Terrain Application," paper presented at 10th International Technical Meeting on Air Pollution Modeling and Its Application, October 23-26, 1979, Rome, Italy.

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5-6 P. B. MacCready, L. B. Baboolal, and P. B. S. Lissaman, "Diffusion and Turbulence Aloft over Complex Terrain," paper presented at AMS Symposium on Atmospheric Diffusion and Air Pollution, Spetember 9-13, 1974, Santa Barbara, California.

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5-8 Preliminary Results of Impact Assessment for Cb Shale Oil, AeroVironment, Inc., Pasadena, California, AV-R-80/549, 1980.

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Section 6

MONITORING PROGRAM

6.1 OBJECTIVES AND RATIONALE OF THE MONITORING PROGRAM

As described in the Environmental Stipulations of the Federal Oil Shale Leases (Ref. 6-1), the monitoring program has several purposes:

- To record the changes that have taken place since the beginning of development operations
- To continuously check compliance with the provisions of the lease and the environmental stipulations
- To check compliance with all applicable federal, state, and local environmental protection and pollution control requirements
- To provide a timely notice of detrimental effects and conditions requiring correction
- To furnish a factual basis for revising or amending the Environmental Stipulations, as provided for in Section 1 (B) thereof

The intent of the Environmental Baseline Data Collection (Ref. 6-2) and subsequent Annual Environmental Progress Reports (Ref. 6-3) was to compile data of sufficient quality and quantity to allow a characterization of conditions existing before the start of development operations. By monitoring selected parameters identified during the baseline program as being reliable indicators of baseline conditions, it will be possible to detect changes that may occur during the life of the project. The duration of the monitoring program will adhere to the requirements of the Environmental Stipulations (Ref. 6-1).

The monitoring plan as presented herein is coordinated with the most probable schedule for facility development as shown in Section 1, Figure 1.4-2. Onsite environmental monitoring programs have continued since 1974. The expanded monitoring program described in this section would be instituted approximately 6 months prior to the start of construction.

6.2 AIR MONITORING

The air quality on Tracts Ua and Ub has been monitored continuously since baseline data collection began in late 1974. Initially the measurement effort was extensive, because no previous data on air quality or meteorology had been collected in the area. As knowledge of baseline pollutant levels was obtained and their general lack of spatial variation was demonstrated, the number of monitoring stations was reduced during the second year of the baseline period. The objectives of these baseline measurements were twofold:

- To characterize the air quality environment in the vicinity of the tracts in sufficient detail to provide a complete description of the baseline situation, against which future air quality could be compared

- To describe the meteorological environment in the vicinity of the tracts in sufficient detail to provide input data for simulation modeling of the dispersion of air pollutants that might be generated by future developments on the tracts

During the subsequent 4 years (1977 to the present), monitoring of air quality has continued at one site and meteorological measurements have continued at four sites. This additional monitoring has provided continuity to the baseline data base and helped satisfy a third objective:

- To determine the year-to-year variation of the baseline air quality and meteorology of the area, in order to see whether the more intensive baseline measurements adequately represented a climatological baseline

As construction and operation phases approach, the air quality monitoring program will take on new objectives:

- To quantitatively determine the air quality impacts of various scales of oil shale development and operation on Tracts Ua and Ub

- To demonstrate that the impacts of the air contaminants emitted by the facilities are in compliance with the National Ambient Air Quality Standards (NAAQS) and the Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act, as well as with Utah air quality standards

- To identify areas where additional control of air contaminant emissions would be appropriate or necessary

- To continue observing the long-term evolution of the regional air quality

This section describes the approach to air monitoring that will be used throughout all phases of the project and after decommissioning. Although it is fairly specific, it should be recognized that all of the air quality impacts of the development are not yet reliably quantifiable; this is because the current knowledge of air pollutant emissions from the facilities is not complete and because today's technology for simulation modeling of the atmospheric transport and diffusion of these emissions over the rugged terrain of the area is still in a state of evolution. Consequently, as further modeling is performed to support permit applications and as data are collected during the growth of the facilities from phase to phase, some changes may be desirable. Changing environmental laws and the continuing evolution of measurement instruments also will provide a basis for change.

The present plan should be viewed to some degree as a statement of approach rather than of all inclusive detail. Adjustments to the monitoring program will be worked out by the White River Shale Project, the Area Oil Shale Supervisor, the Environmental Protection Agency, and the Utah Bureau of Air Quality. Nevertheless, the plan presented here represents the best projection possible at this time of the scope and detail needed for the air quality monitoring program for the project.

6.2.1 OVERVIEW OF THE AIR MONITORING PROGRAM

The ambient air monitoring program will conisst of four groups of measurements:

- Group I: Long-Term Air Quality Evolution. These are continuous measurements at fixed locations, at or near the sites of baseline-period stations whenever possible, to record the continuing long-term evolution of background and regional air quality. They will begin about 6 months before construction affecting the monitoring site begins, continue through all phases of operation, and terminate 1 year after decommissioning of all facilities and restoration of the environment.

- Group II: Direct Impact of Emissions. These are continuous measurements, either on or off tract, that are expected to document the greatest air quality impacts of a particular aspect of the facility. (This group also includes meteorological measurements to help in determining plume transport.) Monitoring sites will be selected initially on the basis of experienced judgment supported by rational dispersion modeling; they may be moved as field surveys identify more appropriate locations and as new facilities are constructed. The number of sites will increase as the scale of the mining and retorting activities increases.

- Group III: Area Impact. These are continuous measurements generally off tract, where the air pollution impact of the facilities could be noticeable (though at levels that are well below all standards or regulations), where the receptor could be sensitive (e.g., a residential community), or where the effect of an adjacent development on the quality of the airflow approaching the tracts could be significant. Such monitoring in the early phases of development would provide guidance for estimating the potential impacts of the later, larger-scale phases, and could serve as an input to their design.

- Group IV: Short-Term Intensive Studies. These are short-term detailed measurements to quantify the actual impact pattern of specific sources, to verify the adequacy of the model-based site selections for the monitoring stations, and to provide data for increasingly improved simulation modeling.

These measurements will provide more than just the minimum of data concerning compliance with air pollution regulations. Rather, in the spirit of the Prototype Oil Shale Leasing Program, they will provide information about the air quality effects of oil shale development as information is developed about oil shale mining and retorting; they may change dynamically as the scale of the development and breadth of technical knowledge grow.

Table 6.2-1 summarizes the proposed monitoring program and Figure 6.2-1 shows the probable locations of the monitoring sites whose general positions can be predicted at this time. The specific location of Site A15 for regional visibility has not yet been selected. Note that several stations serve more than one function, depending on meteorology.

Table 6.2-2 lists the parameters that will be measured on or near the tracts. The abbreviations used in the table are also used in Figure 6.2-1 and in other tables. Table 6.2-3 lists the monitoring program data by site, and Table 6.2-4 lists the data by development phase.

The following sections describe each measurement group, the rationale for each site in detail, the basis for selecting the parameters to be measured, and the methods to be used.

6.2.2 GROUP I MEASUREMENTS: LONG-TERM AIR QUALITY EVOLUTION

The long-term evolution of air quality, referenced against the baseline and pre-construction measurements, is influenced by two things:

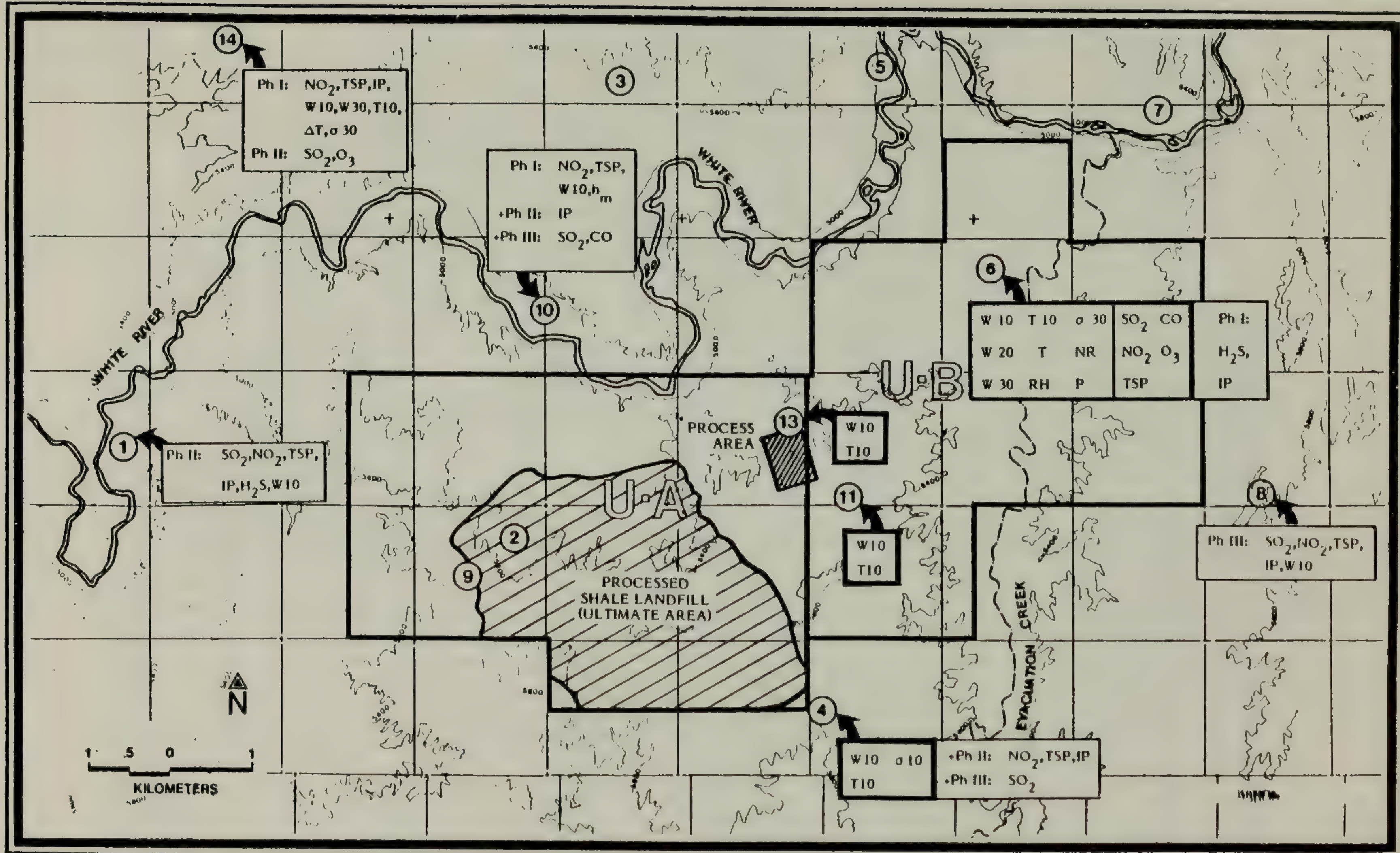
- Factors external to the Ua and Ub development (such as population growth and other energy-resource developments)
- Factors resulting directly or indirectly from the oil shale development on Tracts Ua and Ub

The goal of the Group I measurements is to document this regional evolution.

Table 6.2-1

CONTINUOUS AIR QUALITY AND METEOROLOGICAL MONITORING PROGRAM ON TRACTS Ua AND Ub

Site Number	Measurement Group	Measurement	Beginning of Operation
A1	III	Regional air quality impact in drainage flows	Phase II
A4	II	On-tract meteorology	Currently operational
		Air quality impact south of plant and near processed shale pile	Phase II
A6	I	Background air quality	Currently operational
	II	Plant impact during some transition flows	Phase I
A8	III	Regional air quality impact	Phase III
A10 (relocated)	II	Air quality impact in drainage flows	Phase I
A11	II	On-tract meteorology	Currently operational
A13 (relocated)	II	Plant area meteorology	Currently operational
A14 (new)	I	Background air quality	Phase I
	II	Elevated plume impact during transitional meteorology	Phase I
A15 (new; site to be selected)	I	Regional visibility	Phase I



MEASUREMENTS MADE

MEASUREMENTS TO BE ADDED TO PROGRAM

MONITORING LOCATION (SITES 10 AND 14 ARE NEW SITES)

Figure 6.2-1 CONTINUOUS AIR QUALITY AND METEOROLOGICAL MEASUREMENT SITES ON TRACTS Ua AND Ub

Table 6.2-2

PARAMETERS MEASURED IN AIR QUALITY MONITORING PROGRAM

Type of Monitoring	Parameter
Air Quality	
SO_2	Sulfur dioxide
NO_2	Nitrogen dioxide
CO	Carbon monoxide
O_3	Ozone
H_2S	Hydrogen sulfide
TSP	Total suspended particulate matter
IP	Inhalable particulate matter (d < 15 m)
Visibility	
C_r	Target/sky contrast ratio (measured photographically)
b_s	Light scattering coefficient (measured by integrating nephelometer)
Meteorology	
W10	Wind speed and direction measured at 10 meters above ground level[a]
σ10	Standard deviation of vertical wind speed and horizontal wind direction measured at 10 meters above ground level[a]
h_m	Mixing height (measured by acoustic sounder)
RH	Relative humidity
T10	Temperature, measured at 10 meters above ground level[a]
ΔT	Temperature difference between 10 and 30 meters above ground level
P	Barometric pressure
NR	Net radiation (solar and thermal)

(a) Sites A6 and A14 also include wind, temperature, and turbulence measurements at 20 and/or 30 meters above the ground.

Table 6.2-3

AIR QUALITY MONITORING PROGRAM ON TRACTS Ua/Ub BY PARAMETER[a,b]

Site No.	Air Quality							Visibility		Meteorology							
	SO_2	NO_2	CO	O_3	H_2S	TSP	IP	b_s	C_r	W	σ	T	h_m	RH	ΔT	P	NR
Group I																	
A6[c]	0	0	0	0	I	0	I			0	0	0		0	0	0	0
A14[c]	III	I		III		I	I			I	I	I			I		
A15								I	I								
Group II																	
A4	III	II				II	II			0	0	0					
A10	III	I	III			I	II			I			I				
A11										0		0					
A13										0		0					
Group III																	
A1	II	II			II	II	II			II							
A8	III	III				III	III			III							

(a) Sites are listed by measurement groups, depending on their primary function.
(b) Numerals indicate the project phases in which measurements begin; a zero indicates current measurements.
(c) Sites A6 and A14 also serve as Group II impact monitoring stations under specific meteorological conditions.

Table 6.2-4

AIR QUALITY MONITORING PROGRAM ON TRACTS Ua AND Ub BY DEVELOPMENT PHASE

Site Number	Present (1980)	Phase I[a]	Phase II	Phase III
Group I (Background)				
A6[b]	SO_2,NO_2CO,O_3,TSP W10,W20,W30,T10,ΔT,RH σ30,P,NR	Add H_2S,IP	Continue	Continue[c]
A14[b]	—	NO_2,TSP,IP,W10 W30,T10,ΔT,σ30	Continue	Add SO_2,O_3
A15	—	C_r,b_s,TSP,IP,W10[d]	Continue	Continue
Group II (Impact)				
A4	W10,σ10,T10	Continue	Add NO_2,TSP,IP	Add SO_2
A10	—	NO_2,TSP,W10,h_m	Add IP	Add SO_2,CO
A11	W10,T10	Continue	Continue	Continue
A13	W10,T10	Continue	Continue	Continue
Group III (Area Impact)				
A1	—	—	SO_2,NO_2,TSP, H_2S,IP,W10	Continue
A8	—	—	—	SO_2,NO_2,TSP, IP,W10

(a) Phase I monitoring begins 6 months before Phase I construction.
(b) Sites A6 and A14 also serve as Class II impact monitoring stations under specific meteorological conditions.
(c) Site A6 remains operational for 1 year after abandonment and reclamation.
(d) TSP, IP, and W10 measurements will not be needed at Site A15 if such data is available from another nearby site.

This goal cannot be achieved in the future by measurements from any one site in the area, because all measurement locations can be expected to be impacted at one time or another, to at least a small degree, by operations on the tracts. Consequently, the approach will involve two monitoring sites — the existing Site A6 and a new one to the northwest, at Site A14. At any given time, at least one of the sites will be generally upwind of the tracts, and the measurements there will reflect the quality of the air approaching the plant before any impact of the plant occurs.

The data base that describes the long-term evolution of air quality in the area will be constructed by combining the measurement data from Sites A6 and A14, using the wind direction data to define which site is more representative of the incoming air quality. To enable these data sets to be merged, both sites will be equipped comparably (for all but a few parameters), the air quality instruments at both sites will be identical (same manufacturer and model), and particular attention will be paid to assure comparable operation.

When Sites A6 and A14 are not serving as background monitoring stations, they will serve as impact monitoring stations. This role, which is especially important for Site A14, is discussed in Section 6.2.3.

Sites A6 and A14 have been situated to define the background air quality, which can be considered to be the general ambient air quality of the region. Several major air pollution sources, other than the Ua and Ub developments, are also being planned for the region. The monitoring at Sites A6 and A14 is not designed to necessarily monitor the specific effects of these off-tract sources on the air quality on the tracts. It is assumed that their impacts will be monitored by stations established by those sources specifically for that purpose, and that such monitoring will usually suffice to describe the impacts of these sources on the air quality of the tracts. If this is not the case, the White River Shale Project may perform such measurements of incoming plumes, as discussed in Section 6.2.4.

In addition to the parameters to be measured at Sites A6 and A14, visibility parameters will be measured at Site A15. This site will be at a new location, since Site A9, the location of the baseline visibility measurements, may be affected by dust emissions from the processed shale disposal area; it will therefore not be a representative site for regional-scale visibility characterization.

This monitoring will continue the visibility measurements portion of the baseline data collection period, satisfying an objective of the Prototype Oil Shale Leasing Program pertaining to recording the long-term regional impacts of oil shale development. It is also intended to provide data needed to satisfy the Prevention of Significant Deterioration (PSD) preconstruction requirements in Section 165 of the Clean Air Act, which requires visibility analyses and air quality monitoring for new sources that could potentially impact any Class I PSD area. Since other energy developments are also proposed for this area, a cooperative visibility monitoring program to satisfy the needs of several developments might be appropriate. If this is acceptable to all parties, then Site A15 would be located to best record the regional-scale visibility and plume effects of all proposed developments.

Site A6 is historically the "anchor" baseline air quality monitoring station for the tracts. For this reason, it is proposed that it alone remain in operation for 1 year after the plant has been decommissioned and reclamation efforts have been completed, in order to provide a final data set on the environmental conditions of the area.

6.2.3 GROUP II MEASUREMENTS: DIRECT IMPACT OF Ua/Ub EMISSIONS

Both construction and operation phases of the project can be expected to result in direct impacts on the air quality of some locations in the immediate area. The greatest impact will be felt when the receptor is within a surface-based plume or at a point where an elevated plume impacts the ground.

The air quality analyses presented in Section 5.2 predict that the greatest impacts of surface emissions of particulare matter and SO_2 and of vehicle emissions of NO_2 and CO will occur near the process area, near the shale disposal area, and to the northwest of the process area whenever the air drains downhill toward the White River. Monitoring of these parameters at Sites A4 and A10 will record the impacts of these emissions on the nearby area. Some of these parameters will be monitored during Phase I; monitoring of other parameters will be added as the emissions increase in later phases. Since it is not expected that surface emissions of SO_2 and CO will produce significant air quality impacts during Phases I and II, they will not be monitored at any of these sites until Phase III. Since significant CO impacts are likely only in stable conditions with drainage flow toward the White River, CO monitoring will be performed only at Site A10.

The location used for Site A10 during baseline data collection will ultimately be submerged when the reservoir on the White River is completed. Consequently, a new location for Site A10 will be on somewhat higher ground than the original site.

The anemometers currently operational at Sites A11 and A13 are also in the category of impact monitoring stations, since their measurements will help in analyzing the direction of plume transport. Because the present location of Site A13 is within the proposed process area, the anemometer will be moved a short distance prior to Phase I monitoring.

Because the mixing height and inversion height play such significant roles in determining pollutant dispersion patterns in stable conditions, an acoustic sounder will be installed at Site A10 (rather than the A6 location of the baseline program) so that the atmospheric layering and drainage flow from the plant site down the White River can be observed. Such measurements will help in understanding observed air pollution impacts and modeling the impacts of future phases.

Elevated plume transport in stable conditions, just below or within an inversion aloft, is likely to be the main mechanism of transport of Ua/Ub emissions over distances of more than a few miles. One scenario that is likely to cause the highest off-tract impacts of the plumes from elevated stacks involves early morning plume travel within a stable layer (hence with minimal diffusion) until the stable layer is eroded by thermal mixing from below. This thermal mixing, which usually occurs by mid-morning, can mix the plume to the ground quite rapidly, resulting in a short period of "fumigation" with relatively high concentrations. Studies at other energy developments have shown this type of behavior to be common.

Such fumigation accompanies the change in surface airflow from a drainage condition to a transitional condition (see Figure 2.4-7). The mesoscale drainage flow (which governs plume travel aloft) is from the southwest, and Site A14 is in a location where fumigation could be observed, since it is on a plateau some 5 miles to the northeast of the plant site. The sensors on the 30 meter tower there, with their indications of near-surface stability and turbulence, will help quantify the meteorological conditions related to fumigation, if it is observed. Because of this, Site A14 may also serve as a Group II site.

Site A6 also has a Group II role during the normal westerly daytime airflow, during which it should often record the well mixed plume of most plant emissions.

6.2.4 GROUP III MEASUREMENTS: AREA IMPACT

As pollutants are transported away from Tracts Ua and Ub, they will become mixed by the turbulent air flowing over this topographically complex area; therefore their concentrations will be relatively low over a relatively

large area. Ultimately the source of these added pollutants will no longer be identifiable and they will become part of the background air quality of the area.

To assist in the quantitative assessment of regional-scale identifiable impacts of the Ua/Ub development, two monitoring stations will be located about 4 miles east and west of the plant site. The western location, at Site A1 along the White River, will allow monitoring of the quality of the air leaving the tracts during drainage flows. The eastern location, at Site A8, will provide data on the quality of the air leaving the project area during normal daytime airflow. These two sets of measurements, combined with some impact measurements at Sites A4, A6, and A14, will provide the data base for definitive characterization of the regional scale impacts of the project. Because plant impacts during Phase I are unlikely to be significant at the sites, Site A1 will not become operational until Phase II; Site A8, which will observe the ever smaller daytime impacts, will not be commissioned until Phase III.

The regional-scale assessments require information on the quality of the air coming into the tracts, both in the form of background air and as plumes from nearby sources. The background monitoring function is covered by Sites A6 and A14. Daytime (westerly) flows containing emissions from the proposed Tosco Sand Wash oil shale development 12 miles to the west would be monitored by Sites A1 and A14. Nocturnal drainage flows from the proposed Paraho development 6 miles to the northeast would most probably flow down the White River; the monitoring plan here does not include any provisions for measuring pollutants specifically in the Paraho plume, since that is likely to be a responsibility of the Paraho development. The plume from a third facility, a proposed coal-fired electric generating station 15 miles north of the tracts, is unlikely to have a significant effect on the annual air quality of the tracts because persistent northerly winds are quite rare; Site A14 is best sited to observe any such impacts, if they do occur.

Site A1 is one of two sites monitoring H_2S. Although significant H_2S emissions are unlikely, the effects of such emissions should be most noticeable in stable drainage flows. As a downdrainage station, Site A1 would most probably be the only site to observe any H_2S, and therefore will commence H_2S monitoring during Phase II. Site A6 will also monitor H_2S in order to characterize any changes in the H_2S concentrations in the background air.

6.2.5 CLASS IV MEASUREMENTS: SHORT-TERM INTENSIVE STUDIES

The phased development of Tracts Ua and Ub is highly conducive to a program of careful analysis of the air quality impacts of the project. Actual impacts of the first phase can be studied to provide information for the environmentally effective design of the next phase, and to more effectively assess future air quality impacts.

The same scenario would be followed after the Phase II operations begin. Air quality data would be collected by the monitoring network for at least 1 year, and the data would be analyzed to determine conditions under which air quality impacts are significant, and the locations of these impacts. It is possible that the data will suggest that peak impacts will occur at other than the station locations. Consideration will then be given to relocating the station(s).

To better define the precise locations and magnitudes of peak impacts, special short-term field studies might be performed. Such studies could include more intensive monitoring of plant impacts using additional monitoring equipment or mobile monitors. In some cases, tracer gases or particulate matter tracers might be used to allow better definition of the impacts of specific actual sources, or of sources that are proposed for the next phase. These studies would take place for a few weeks during those times of the year that the monitoring data show to be of most concern.

The information from these studies would serve several purposes:

- It would indicate whether some monitoring stations should be relocated.
- It would allow the impacts of plant operations to be evaluated and the procedures for predicting these impacts to be refined. As a result, the design of some plant components proposed for the next phase might be changed, or the simulation modeling techniques used to predict impacts might be refined.
- It would provide a data base for more realistic modeling of the impacts of the next phase of development. This data could also provide information for improved definition of the actual consumption of PSD increments as well as for more precise analysis of plant impacts.

If other regulated pollutants are emitted by the process in significant quantities, studies could also include measurements of such pollutants to quantify their concentrations in the ambient air. Pollutants that might be of interest in such studies could include non-methane hydrocarbons, sulfuric acid mist, and polycyclic organic matter (if these emissions become the subject of regulations).

6.2.6 MEASUREMENT METHODS

Table 6.2-5 lists the measurement methods to be used and the frequency of assessments for each of the parameters to be monitored. Details of the measurement methods for such parameters are discussed below.

6.2.6.1 Air Quality

Of the air quality parameters listed in Table 6.2-5, a national ambient air quality standard (NAAQS) has been established for SO_2, NO_2, CO, O_3, and TSP. Although an NAAQS has not been established for H_2S, it is regulated by the Clean Air Act. Since small emissions of H_2S will occur routinely and greater emissions could occur during mining and in process

Table 6.2-5

AIR QUALITY MEASUREMENT METHODS AND FREQUENCY

Parameter	Measurement Method	Measurement Frequency
Air Quality		
SO_2	Pulsed fluorescence	Continuous
NO_2	Chemiluminescence	Continuous
CO	Non-dispersive infrared absorption	Continuous
O_3	Chemiluminescence	Continuous
H_2S	Conversion to SO_2; pulsed fluorescence	Continuous
TSP	High-volume sampler	Every 6 days
IP	Size selective inlet high-volume sampler	Every 6 days
Visibility		
C_r (contrast)	Photography and densitometry	1 day each month
b_s (light scattering)	Integrating nephelometer	Continuous
Meteorology		
Wind	Cup and vane anemometer	Continuous
σ (turbulence)	Calculation of r.m.s. wind direction and vertical wind speed fluctuations	Continuous
h_m (mixing height)	Acoustic sounder	Continuous
RH	Hygrometer	Continuous
T	Thermistor in aspirated shield	Continuous
ΔT	Matched thermistors in aspirated shields	Continuous
P	Aneroid barometer	Continuous
NR (net radiation)	Fritschen net radiometer	Continuous

upsets, some H_2S monitoring is proposed. H_2S was also monitored during the baseline data collection period. Inhalable particulate matter (IP) is likely to be regulated by an NAAQS in 1981; the proposed monitoring program allows for this eventuality.

Although NAAQS exist for non-methane hydrocarbons (NHMC) and lead, the standards are not relevant for this geographic area nor for the oil shale process. Consequently no monitoring of either of these pollutants is proposed. The Area Oil Shale Supervisor has recognized that NMHC measurements are not a necessary element of an air quality program for such developments, and has relieved all prototype lease operators from the requirement for further NMHC monitoring.

Other pollutants regulated by the Clean Air Act, but not under NAAQS, will be included into the total air monitoring program if there is evidence that emissions of such pollutants might occur at levels that would exceed the monitoring exemption provisions of the PSD regulations (40 CFR 51.24(i)). Continuous monitoring of such pollutants is unlikely to be needed in any case, but short-term field surveys of specific pollutants might be included in Group IV monitoring. Pollutants in this category include total reduced sulfur (including H_2S, which was discussed above) and H_2SO_4 mist. Polycyclic organic matter (POM), which is of interest because of its potential carcinogenicity, might also be included if proposed emission standards (NESHAP) for POM are implemented. The remaining regulated pollutants, such as asbestos, Be, Hg, fluorides, vinyl chloride, benzene, and As, are unlikely to be of concern.

The baseline data showed that ambient radioactivity in the air, particulate matter, soil, water, and plants was well within normal levels. Radioactivity analyses of drill core samples from the mining zone also showed normal levels of radioactivity. Consequently no radioactive impacts of the development are expected and no radioactivity monitoring is proposed. Similarly,

no significant inorganic carcinogen emissions from the process have been identified and therefore no monitoring of such materials is proposed. In both cases, there is no regulatory requirement for such monitoring.

A monitoring plan and quality assurance manual will be prepared for each phase of monitoring, and they will be submitted to the Area Oil Shale Office, the EPA, and the Utah Bureau of Air Quality.

All of the air quality measurements will be performed in conformance with the EPA "Ambient Monitoring Guidelines for the Prevention of Significant Deterioration (PSD)." The monitoring of NAAQS pollutants will be performed using EPA-designated "reference" or "equivalent" methods, in conformity with the provisions of 40 CFR 53.

The quality assurance program will conform to the PSD Guidelines, the EPA "Quality Assurance Handbook for Air Pollution Measurement Systems," and with Appendix B of 40 CFR 58, "Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring." The quality assurance program will include span and zero checks of each analyzer at least twice each week, precision checks at least once every two weeks, multipoint calibrations monthly, audits of instrument performance quarterly, and participation in EPA's national performance audit program. A "control" high-volume sampler will be operated at Site A6 to satisfy the quality assurance elements of the PSD monitoring guidelines.

6.2.6.2 Visibility

To describe the visibility of the region, the visibility measurements of the baseline data collection program will be resumed with quantitative measurement of vista/sky contrast and the light-scattering ability of the ambient aerosol. The technology of visibility measurement is developing rapidly and the measurement techniques to be used will be improvements of the methods used in the baseline program.

The contrast of selected remote targets against the horizon sky, C_r, will be recorded photographically, using a camera with a 10X or stronger telephoto lens. The image will be recorded on black-and-white film through a filter that matches the film spectral response to that of the eye; a standard gray scale will be exposed on the end of each film; and the target/sky contrast will be read with a densitometer. Since the objective of this program is the observation of long-term visibility trends, such measurements will be made on one fixed day of each month, with observations made at three times on that day. Concurrent color photographs of each vista, using more normal lenses, will display the conditions under which the contrast measurements were being made.

Continuous measurements of light scattering coefficient, b_s, will be made at the visibility site to provide a record of the diurnal and daily variation of the optical effects of the atmospheric aerosol, and will allow testing of the representativeness of the days used for the photographic procedure. Concurrent measurements of TSP and IP at the same location, or at a nearby location, will allow deduction of relationships between light scattering and aerosol mass concentration; wind data will indicate the direction of the probable source.

Insofar as is relevant for this study, the procedures used for visibility measurement will follow the EPA document, "Interim Guidance for Visibility Monitoring." The photographic process to be used has been shown by Allard and Tombach (Ref. 6-4) to be equivalent to the telephotometer in the EPA guideline.

6.2.6.3 <u>Meteorology</u>

The meteorological parameters to be monitored during the operational period are primarily those monitored during the baseline data collection period. In most cases they are being measured to provide continuing information on the motion of the atmosphere, to allow analysis of the behavior of the potential or actual air pollutant emissions from the plant.

The methods for meteorological measurement will also follow the EPA "Ambient Monitoring Guidelines for the Prevention of Significant Deterioration" whenever appropriate.

6.2.7 DATA ANALYSIS

All the measurements described above, with the exception of the particulate sampling and the contrast and mixing height measurements, will be recorded on computer tape, with backup recording on strip charts. The data will then be reduced and analyzed, as described below.

6.2.7.1 Data Reduction

Data from the records will be processed, edited, and calibrated to produce hourly, daily, monthly, and annual averages of each parameter as appropriate. In addition, for those pollutants for which 3-hour, 8-hour, or 24-hour averages exist, cooresponding running averages will be computed. Values that exceed applicable standards will be identified and reported to AOSS, EPA, and UBAQ.

A gray scale will be exposed on the black-and-white visibility photograph film by a sensitometer before development, and target/sky contrast ratios for selected targets will be determined by a densitometer. (The process is described in detail in Reference 6-5.) These contrast ratios will then be used to estimate the visual range corresponding to each observation; observations corresponding to unusual viewing conditions will be flagged to allow separate analysis.

The filters for TSP measurements will be weighed before use on an analytical balance (0.05 mg resolution) and filters for the IP measurements will be weighed on a microbalance (0.0001 mg resolution). After exposure they will be weighed again to determine the total collected mass, and therefore the aerosol mass concentration corresponding to the particle size ranges collected by the sampler.

Mixing height information will be determined through analysis of the acoustic sounder records by a meteorological technician, who will tabulate hourly averages of both mixing height and the height of the inversion top.

All the manually processed data will be merged with the computer tape data from the continuous sensors to form a complete data base for subsequent analysis.

6.2.7.2 Data Analysis

Data collected by the air quality and meteorological stations will be analyzed to answer two questions:

- Do monthly and annual means of air quality, visibility, and meteorological parameters change over time; i.e., are there any long-term trends? (For some parameters the geometric mean or the total is the appropriate unit, in place of the monthly or annual arithmetic mean.)
- Do hourly or daily means of air quality parameters differ from one site to the next; i.e., do Ua/Ub sources (or other nearby sources) influence the local air quality?

Time series analysis procedures (Box Jenkins analysis) can be used to address the first question when several years of data exist for a given parameter. Because meteorological factors have such a significant effect on air pollution means, time series analyses of air quality data are usually not informative unless more than 10 years of data are available or unless the parameters being studied are changing rapidly. The data can be adjusted to correct for some meteorological factor in order to identify trends over shorter periods. Simpler analyses of the variations in means are appropriate for parameters that are changing rapidly or are relatively insensitive to meteorology.

The second question is most easily addressed comparing values at pairs of sites, in terms of their hourly or longer-term mean differences. Since the baseline data showed that most air quality parameter values did not vary over the study area, such comparisons will identify which stations

are exhibiting impacts due to local sources, and what the magnitudes of these impacts are. Of course, the data have to be stratified by meteorological categories, to clearly identify the impacted sites for each category and to allow the impacts to be related to their sources.

TSP concentrations during the baseline period were not uniform from site to site, but rather reflected the effects of unavoidable local traffic and of localized meteorological variations. As was shown by Tombach and Chan (Ref. 6-6), the annual geometric mean of TSP concentrations was a factor of two greater for those sites within 100 meters of existing roads than for those sites well removed from roads. Thus, there was spatial variability in TSP concentrations during the baseline period. Such differences can be expected to increase once plant construction begins for Phase I. In most cases, the plant impacts on TSP levels are likely to be greater than the baseline variations, so no ambiguity is expected about which sites are impacted by the Ua/Ub developments. However, at the more remote sites, the historical background trends may be needed to evaluate whether any impacts are occurring.

6.2.7.3 Contingency Plan

The data will also be evaluated to determine whether the information being gathered is meeting its intended purpose. For example, if it is found that the measured wind seldom blows from the process area toward an intended impact monitoring station, then it may be appropriate to move the station. Similarly, if a background station shows regular impacts from local sources, it may not be in the proper location.

If there is a doubt about the continuous monitoring data representing the background or impact levels properly, or about the probable peak impacts being missed, then a Group IV study will be performed to understand the actual situation and to identify the needed corrective action. Subsequently, after coordination with the Area Oil Shale Supervisor, the EPA, and the Utah Bureau of Air Quality, the monitoring program will be changed as needed. This could include the number or location of analyzers or stations, the frequency of measurements, or the parameters being measured.

6.3 WATER MONITORING

The proposed water monitoring program reflects the results of the environmental baseline data collected to date, plus the results of experimental studies conducted on representative processed oil shales. The proposed program is also responsive to the lease stipulations, EPA's NPDES discharge requirements, and the Utah wastewater disposal regulations. The program will be implemented at least 6 months before Phase I begins. Before Phase II begins, it will be reassessed on the basis of expected future development activities, and the analysis of processed shale and processed shale leachate produced during Phase I.

6.3.1 SURFACE WATER

Flow measurements and continuous or intermittent sampling of surface waters for physical and chemical constituents will be carried out at selected stations in order to monitor environmental quality during development and operation of the mining and processing facilities on the tracts.

6.3.1.1 Water Quantity

Streamflow Measurements. Continuous streamflow records will be collected at the locations shown in Table 6.3-1 and Figure 6.3-1. The stations in Southam Canyon (09306605 and 09306610) and in Asphalt Wash (09306625) are expected to have zero flow during most days of the year. A gauging station will be established on the small tributary to the White River that drains the proposed plant site area. The exact location of this station has not been determined at this time, but it will be located downstream of the proposed wastewater holding basin. This station is also expected to have zero flow during most days of the year.

Station 09306610 at the mouth of Southam Canyon will have to be relocated further upstream when the White River reservoir is formed. This new location would still be downstream of the retention dam near the boundary of

LEGEND:

- ● EXISTING STREAMFLOW GAUGING STATION AND WATER QUALITY SAMPLING STATION
- ▲ PROPOSED STREAMFLOW GAUGING STATION AND WATER QUALITY SAMPLING STATION (APPROXIMATE LOCATION)
- ■ PROPOSED LOCATION FOR PRECIPITATION GAUGE

Figure 6.3-1 SURFACE WATER MONITORING SITES

6.3 WATER MONITORING

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Figure 6.3-1 SURFACE WATER MONITORING SITES

Table 6.3-1

LOCATIONS OF EXISTING STREAMFLOW GAUGING STATIONS

U.S. Geological Survey Station Number	Station Location
09306395	White River near Colorado-Utah State Line, Utah
09306420	Evacuation Creek at Watson, Utah
09306430	Evacuation Creek near Watson, Utah
09306605	Southam Canyon Wash near Watson, Utah
09306610	Southam Canyon Wash at mouth, near Watson, Utah
09306625	Asphalt Wash near mouth, near Watson, Utah
09306700	White River below Asphalt Wash, near Watson, Utah

Tract Ua. If Station 09306605 is threatened with burial under processed shale, it will be relocated an adequate distance upstream and, if necessary, off tract.

On-Tract Impoundments. The volume of water in the project impoundments will be monitored by measuring the depth of water, as shown by a permanently mounted staff gauge. In addition, an automatic water level recorder may be used for certain impoundments. The depth of sediment in the impoundment will also be monitored so that the actual water volume and capacity of the impoundment can be determined.

Precipitation. Precipitation will be monitored by automatic recording gauges or storage gauges at nine locations distributed throughout the tracts to accurately describe variations in precipitation. The preliminary locations of these gauging stations are shown in Figure 6.3-1 and are listed in Table 6.3-2.

Table 6.3-2

LOCATIONS OF PRECIPITATION GAUGING STATIONS

Number	Location
RV-7	At the revegetation study site north of the White River and near Site A-7
RV-8	At the revegetation study site close to Evacuation Creek and near Wells G-8 and G-8A
ARA-13	At Site A-13 and the plant site
RA-4	At Site A-4
RS-11	Near Site A-1 and Station 09306700
RVG-3	Near Site VG-3
RS-13	At Station 09306610
ARS-9	At Station 09306605
ARA-2	At Site A-2

The designations beginning with the letter "A" are automatic recording gauges; the designations beginning with the letter "R" are storage gauges. The first six stations will be operated year round. The remaining three will be operated only during the thunderstorm season (approximately March through October) to gain information on single thunderstorm intensity in the Southam Canyon drainage.

Evaporation. An evaporation pan will be operated at the plant site during the freeze-free period (approximately May through September). The data will be used to determine evaporation losses from open water bodies, such as the wastewater holding basin.

6.3.2.2 Water Quality

All water quality and suspended sediment samples will be collected using standard field equipment and techniques, as described in Techniques of Water Resources Investigations of the U.S. Geological Survey (Ref. 6-7) and in National Handbook of Recommended Methods for Water-Data Acquisition (Ref. 6-8). Laboratory analysis of the water samples will be determined according to procedures described in Reference 6-7. Where appropriate, laboratory methods for the analysis of certain constituents will be those listed in Standard Methods for Examination of Water and Wastewater (Ref. 6-9) or methods approved by the Area Oil Shale Supervisor.

The parameters to be analyzed and the frequency of sample collection may be modified depending on the results of the ongoing program. For example, if a perturbation in surface water quality is being detected at a location and it appears to be caused by project-related activities, the monitoring intensity for that location and locations downstream would be increased in order to determine the source and cause of the perturbation, as well as the effects upon the environment. This is discussed in more detail in Section 6.3.5.

White River. Two water quality parameters, temperature and specific conductance, will be monitored continuously at the two stations on the White River (stations 09306395 and 09306700).

Suspended sediment samples will be collected at varying frequencies, depending on the streamflow conditions. The U.S. Geological Survey is expected to be responsible for all suspended sediment data collection and

reduction at station 09306395. Therefore, the following description applies only to station 09306700. During peak runoff, especially during and following intense thunderstorm runoff, samples will be collected up to four times daily. An automatic pumping sampler (Model PS-69) will be used at this station to supplement manually collected samples during most of the year. During stable baseflow conditions, samples will be collected less frequently and will range from once daily during the summer and fall to once a week during the winter. It is expected that the automatic pumping sampler will not be operable during most of the winter due to severe icing conditions. Generally, the frequency of sampling will be designed so that sediment transport can be accurately determined.

Water samples will be collected quarterly at stations 09306395 and 09306700 for laboratory analysis of the parameters listed in Table 6.3-3. As shown in the table, additional parameters will be analyzed semi-annually. The quarterly sampling is expected to occur in March, June, September, and December. The semi-annual sampling will occur during peak runoff from snowmelt (June) and during the late summer baseflow period (September). Several parameters will be measured in the field at the time of sample collection. These parameters are instantaneous streamflow, water temperature, specific conductance, pH, and dissolved oxygen.

During the initial portion of the development monitoring program, some additional water quality samples will be collected in support of the aquatic ecology studies. These efforts will not be continued as part of the regular program.

The frequency of analysis for certain parameters is expected to be greatly reduced after the first 2 years of the development monitoring program. Since the project is not expected to involve any discharges to the White River or Evacuation Creek, the purpose of the monitoring program will be to provide a current description of the baseline condition of these

Table 6.3-3

PARAMETERS FOR LABORATORY ANALYSES OF
SURFACE WATER QUALITY FOR TRACTS Ua AND Ub

Determined Quarterly and Semi-Annually	Determined Semi-Annually Only
Alkalinity as $CaCO_3$, total	Aluminum, dissolved
Bicarbonate	Ammonia, dissolved
Boron, dissolved	Arsenic, dissolved
Calcium, dissolved	Barium, dissolved
Carbonate	Beryllium, dissolved
Chloride, dissolved	Bismuth, dissolved
Fluoride, dissolved	Bromide
Hardness as $CaCO_3$, total	Cadmium, dissolved
Magnesium, dissolved	Chemical oxygen demand
Nitrate as N, dissolved	Chromium, dissolved
Nitrite as N, dissolved	Cobalt, dissolved
Organic Carbon, dissolved[a]	Color
pH	Copper, dissolved
Potassium, dissolved	Cyanide
Silica as SiO_2, dissolved	Gallium, dissolved
Sodium, dissolved	Germanium, dissolved
Sodium adsorption ratio	Gross alpha[b]
Sodium percent	Gross beta[c]
Solids, dissolved (calculated)	Iron, dissolved
Solids, dissolved (residue at 180C)	Lead, dissolved
Solids, suspended	Lithium, dissolved
Specific conductance	Manganese, dissolved
Sulfate, dissolved	Mercury, dissolved
	Molybdenum, dissolved
	Nickel, dissolved
	Oil and grease
	Organic nitrogen as N, total
	Orthophosphorus as P, dissolved
	Phenols
	Phosphorus as P, total
	Selenium, dissolved
	Silver, dissolved
	Strontium, dissolved
	Sulfide, total
	Tin, dissolved
	Titanium, dissolved
	Turbidity
	Vanadium, dissolved
	Zinc, dissolved
	Zirconium, dissolved

(a) If the dissolved organic carbon (DOC) value exceeds the baseline mean values by four times or if significant trends in DOC are identified, the laboratory will analyze DOC fractionation into six parts (the acid, base, and neutral fractions of the hydrophobics and hydrophilics).
(b) If gross alpha activity is measured at greater than 4 picoCuries/liter, the laboratory will analyze for radium 226 and for natural uranium.
(c) If gross beta activity is measured at greater than 100 picoCuries/liter, the laboratory will analyze for strontium 90 and cesium 137.

perennial watercourses. This baseline will probably change slowly due to upstream development activities. It may be adequate to analyze for the comprehensive list of parameters during 1 year out of every 5, rather than during every year for the life of the project. The results of the analyses for quarterly and shortened semi-annual parameters should be adequate to indicate any changes in the baseline conditions. If these analyses indicate that baseline conditions have changed, the comprehensive analyses of water quality could be resumed at appropriate locations.

Evacuation Creek. Temperature and specific conductance will be measured continuously at stations 09306420 and 09306430.

Suspended sediment samples will be collected at both stations at varying frequencies, depending on the streamflow conditions. Sample collection will be most intense during the snowmelt runoff period and during and following runoff from intense thunderstorms. The number of samples collected will vary from one to several per day depending on the degree of streamflow variation. During the stable baseflow period, samples will be collected weekly. All suspended sediment samples will be collected manually.

The schedule and scope of field and laboratory water quality analyses for the Evacuation Creek stations is the same as for the White River stations, except that the quarterly sampling is expected to occur in January, April, July, and September, with the semi-annual sampling in April and September.

Southam Canyon. Temperature and specific conductance will be measured continuously at stations 09306605 and 09306610.

Suspended sediment samples will be collected during all runoff events, if possible. Samples will be collected manually.

Water quality samples will be collected at both stations during all runoff events, if possible. The field water quality measurements previously described will be made during sample collection. All water samples will be analyzed for the semi-annual list of parameters shown in Table 6.3-3.

Plant Site Drainage. The schedule and scope of water quality monitoring for the proposed station below the plant site will be the same as for the Southam Canyon stations. Water samples will be collected during all runoff events, if possible.

Asphalt Wash. The schedule and scope of water quality monitoring for station 09306625 will be the same as for the Southam Canyon stations.

On-Tract Impoundments. At the retention dam pond below the processed shale pile, a water sample will be collected immediately following each runoff event. All samples will be analyzed for the semi-annual list of parameters shown in Table 6.3-3. Field measurements of water quality will also be made during sample collection.

At the wastewater holding basin at the plant site, water samples will be collected and field measurements of water quality will be made quarterly. All water samples will be analyzed for the semi-annual list of parameters shown in Table 6.3-3.

All water samples will be analyzed for a six-part fractionation of dissolved organic carbon. This will continue until a trend can be established, at which time analysis will revert to the conditional situation given in the footnote of Table 6.3-3.

6.3.1.2 Program Rationale

Water Quantity. The gauging station locations were selected to ensure that surface water movement on or near the tracts will be monitored. The two stations on the White River are located upstream and downstream of the tracts. The two stations on Evacuation Creek are upstream and downstream of areas of major project activity. The two stations in Southam Canyon are upstream and downstream of the processed shale disposal area. Station 09306625 in Asphalt Wash is downstream of the drainage that includes the western portion of Tract Ua. This part of the tract is expected to remain undisturbed, so this monitoring station can also serve as a control station to indicate any long-term natural changes in surface water hydrology and quality. The new station located downstream of the plant site will monitor any unintended discharges from the wastewater holding basin. Monitoring of the volume of water within the project impoundments will provide required information for water balance determinations and other project-related studies.

Water Quality. The monitoring parameters listed in Table 6.3-3 were chosen primarily because they:

- Are included in the state of Utah water quality standards applicable to the White River and its tributaries
- Are indicators of a pollution source
- Could reach potentially toxic levels within project wastewater or leachate
- Are required for interpretive analysis of the water quality and/or aquatic ecology monitoring results

The division between quarterly and semi-annual frequency of analysis was based primarily on a priority ranking of sources and pollutants for Tracts Ua and Ub (Ref. 6-10).

The monitoring program in the vicinity of the plant site and the processed shale disposal area is designed to characterize the contaminated water on the tracts, and to provide early detection and tracking of any unintended release of this water from the impoundments.

Continuous monitoring of specific conductance (which is an indicator of dissolved solids concentration) in combination with periodic collection of water samples for chemical and physical analysis should be adequate to detect any project-related effects on the perennial watercourses (White River and Evacuation Creek) near the tracts if any unintended releases of contaminated water or pollutants occurs.

Since most transport of dissolved and suspended material occurs during peak flow periods, the complete list of water quality parameters should be analyzed for samples collected during peak flow. During the late summer baseflow period, many constituents reach their maximum annual values. Therefore, it is appropriate to analyze samples for the complete list of parameters at this time, because the concentrations of certain limiting parameters may be at a maximum even though the transport of dissolved and suspended material is low.

6.3.2 GROUNDWATER

Groundwater quality and static water levels will be monitored in wells completed to alluvial, Bird's Nest, and Upper (Uinta Formation) aquifers.

6.3.2.1 Program Design and Methodology

The development schedule and location of the processed shale disposal pile, process area, and retention dams must be known in advance to establish well locations. Some existing wells may not be usable throughout project development, but may be used for monitoring for a portion of project development. Certain existing wells may be extended upward during construction and processed shale filling operations. New wells will be needed to replace some existing wells, and additional wells may be needed in areas where

perturbations to groundwater quality may initially occur. The number, design, and location of new monitor wells will be determined in consultation with the Area Oil Shale Supervisor.

Table 6.3-4 lists the existing wells to be used for monitoring static water levels; these levels will be measured with an electric probe or similar device prior to sampling. The selected existing monitor well locations are shown in Figure 6.3-2.

Table 6.3-4

EXISTING WELLS TO BE USED FOR MONITORING GROUNDWATER LEVELS

Well Number	Geologic Unit Monitored
G-2A[a]	Alluvium
G-4A[a]	Alluvium
AG-6[a]	Alluvium
AG-7[a]	Alluvium
P-2 Upper[a]	Uinta Formation
P-1	Bird's Nest Aquifer
P-2 Lower[a]	Bird's Nest Aquifer
G-5 or G-11[a]	Bird's Nest Aquifer
P-3	Bird's Nest Aquifer
G-8A	Bird's Nest Aquifer
G-10	Bird's Nest Aquifer
G-14[a]	Bird's Nest Aquifer
G-15[a]	Bird's Nest Aquifer
G-21	Bird's Nest Aquifer

(a) Location will be affected by construction of the White River reservoir, plant site, or by the disposal of processed shale.

Figure 6.3-2 EXISTING GROUNDWATER MONITORING WELLS

perturbations to groundwater quality may initially occur. The number, design, and location of new monitor wells will be determined in consultation with the Area Oil Shale Supervisor.

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G-4A[a]	Alluvium
AG-6[a]	Alluvium
AG-7[a]	Alluvium
P-2 Upper[a]	Uinta Formation
P-1	Bird's Nest Aquifer
P-2 Lower[a]	Bird's Nest Aquifer
G-5 or G-11[a]	Bird's Nest Aquifer
P-3	Bird's Nest Aquifer
G-8A	Bird's Nest Aquifer
G-10	Bird's Nest Aquifer
G-14[a]	Bird's Nest Aquifer
G-15[a]	Bird's Nest Aquifer
G-21	Bird's Nest Aquifer

(a) Location will be affected by construction of the White River reservoir, plant site, or by the disposal of processed shale.

Figure 6.3-2 EXISTING GROUNDWATER MONITORING WELLS

Monitoring frequency for static water level measurements will be quarterly for alluvial wells and semi-annually for bedrock aquifer wells. Anticipated monitoring dates for a semi-annual program are during June and December. Additional collection dates for quarterly monitoring are during March and September. The continuous water level monitoring at wells P-1, P-2 upper, P-2 lower, and P-3 will be continued for the development monitoring program.

Table 6.3-5 lists the existing wells for monitoring groundwater quality. Water samples will be collected from monitoring wells by pumping or with a thief sampler. The alluvial wells will initially be sampled semi-annually. When the Phase I retorting operations begin, the frequency of sampling will be increased to quarterly. The bedrock aquifer wells will be sampled annually (during May or June) throughout project operations.

Table 6.3-5

EXISTING WELLS TO BE USED FOR MONITORING
GROUNDWATER QUALITY

Well Number[a]	Geologic Unit Monitored
G-2A	Alluvium
G-4A	Alluvium
AG-6	Alluvium
AG-7	Alluvium
P-2 Upper	Uinta Formation
P-2 Lower	Bird's Nest Aquifer
G-5 or G-11	Bird's Nest Aquifer
G-15	Bird's Nest Aquifer
G-21	Bird's Nest Aquifer

(a) All but Well G-21 will be affected by construction of the White River reservoir, the plant site, or by the disposal of processed shale.

Water collected from all wells will be analyzed in a laboratory following the methods described in Reference 6-7. Where appropriate, laboratory methods for the analysis of certain constituents will be those listed in Reference 6-9 or methods approved by the Area Oil Shale Supervisor. Groundwater quality will be analyzed for the parameters shown in Table 6.3-6.

More frequent monitoring may be performed if it is apparent from the data collected that water quality and/or groundwater flow is being affected by project development. Monitoring may also be extended to include additional wells, if necessary.

6.3.2.2 Program Rationale

The rate of groundwater movement is relatively slow, so the location of monitoring sites is critical for detecting pollution before a significant buildup occurs in the system. The greatest potential source of groundwater contamination may be the processed shale pile, which covers predominantly non-water-bearing soil, alluvium, and bedrock. Any water that percolates through the processed shale will leach organic and inorganic materials, and this leachate may reach the underlying unsaturated bedrock.

A small amount of leachate may reach the water table of the Bird's Nest Aquifer, about 400 to 600 feet below ground surface, after an unknown period of time. Leachate movement will be primarily through the unsaturated zone. Monitor wells within this zone will be located where leachate is most likely to escape, e.g., in alluvial channels at the following locations:

- Upgradient of processed shale disposal area (for monitoring background conditions)
- Downgradient of process area wastewater holding basin
- Downgradient of Southam Canyon retention pond
- At the toe of the processed shale pile

Table 6.3-6

MONITORING PARAMETERS FOR LABORATORY ANALYSIS OF GROUNDWATER QUALITY FOR TRACTS Ua AND Ub

Alkalinity as $CaCO_3$, total	Mercury, dissolved
Aluminum, dissolved	Molybdenum, dissolved
Ammonia as N, dissolved	Nickel, dissolved
Arsenic, dissolved	Nitrate as N, dissolved
Barium, dissolved	Nitrite as N, dissolved
Beryllium, dissolved	Oil and grease
Bicarbonate	Organic carbon, dissolved[c]
Bismuth, dissolved	Organic nitrogen as N, total
Boron, Dissolved	Orthophosphorus as P, dissolved
Bromide	pH
Cadmium, dissolved	Phenols
Calcium, dissolved	Phosphorus as P, total
Carbonate	Potassium, dissolved
Chemical oxygen demand	Selenium, dissolved
Chloride, dissolved	Silica as SiO_2, dissolved
Chromium, dissolved	Silver, dissolved
Cobalt, dissolved	Sodium, dissolved
Copper, dissolved	Sodium adsorption ratio
Cyanide	Sodium percent
Fluoride, dissolved	Solids, dissolved (calculated)
Gallium, dissolved	Solids, dissolved (residue at 180C)
Germanium, dissolved	Specific conductance
Gross alpha[a]	Strontium, dissolved
Gross beta[b]	Sulfate, dissolved
Hardness as $CaCO_3$, total	Sulfide, total
Iron, dissolved	Tin, dissolved
Lead, dissolved	Titanium, dissolved
Lithium, dissolved	Vanadium, dissolved
Magnesium, dissolved	Zinc, dissolved
Manganese, dissolved	Zirconium, dissolved

(a) If gross alpha activity is greater than 4 picoCuries/liter, the laboratory will analyze for radium 226 and natural uranium.

(b) If gross beta activity is greater than 100 picoCuries/liter, the laboratory will analyze for strontium 90 and cesium 137.

(c) If the dissolved organic carbon (DOC) value exceeds the baseline mean by four times or if significant trends in DOC are identified, the laboratory will analyze for DOC fractionation into six parts (the acid, base, and neutral fractions of the hydrophobics and hydrophilics).

The potential for movement of pollutants into the unsaturated zone appears to be greatest near the toe of the processed shale pile. This toe will gradually move downslope, so a series of wells will be required. They should be placed at the initial toe of the pile and then be gradually replaced with other wells as the pile advances. New wells will be installed further downslope or in nearby alluvial channels, and old wells will be abandoned in accordance with the regulations of the state of Utah. The total number of sequential wells required during the life of the project will be determined, in consultation with the Area Oil Shale Supervisor, after the program is under way. It should be noted here that proposed federal regulations for hazardous waste disposal require a minimum of one well upgradient and three wells downgradient of a hazardous disposal area (Ref. 6-11). However, at the present time, EPA has not made a final determination as to whether processed shale will be considered a hazardous waste.

The bedrock aquifers may be affected by deep percolating leachate and/or by subsidence of the mined zone. Water quality and static water levels will be measured in existing wells (see Tables 6.3-4 and 6.3-5) to monitor these effects.

The parameters in Table 6.3-6 were chosen because they are: 1) potential contaminants or indicators of contamination that may be caused by project activities or 2) parameters required for interpretive analysis of groundwater quality and its relationship to surface water quality.

Water level fluctuations will be monitored to determine changes in groundwater storage and flow direction, which may occur due to project activites.

6.3.3 WATER WITHIN THE UNSATURATED (VADOSE) ZONE

Described below is the program that will be implemented prior to and during Phase I development in order to monitor water within the unsaturated (vadose) zone.

Generally, the vadose zone is defined as that subsurface region extending from the ground surface to the water table. The first primary aquifer encountered at depth and which underlies most of the oil shale tracts is the Bird's Nest Aquifer. (See Section 2.3 for more information.) Accordingly, the vadose zone is defined as that region extending from the land surface to the interface between the confining Green River Formation mudstone and the Bird's Nest Aquifer. In vertical extent, the vadose zone consists of approximately 500 feet of Uinta sandstones with interbedded siltstones and mudstones.

The indigenous vadose zone will be modified during Phase I development at the process area and at the processed shale disposal area. The modifications will primarily involve grading, redistribution of surface material, and solid waste disposal. In addition, mine access shafts will penetrate the vadose zone in the vicinity of the process area.

Of primary concern with respect to pollution potential is the processed shale pile in Southam Canyon. In addition, the wastewater holding basin in the process area could release water into the vadose zone if leakage occurs. Accordingly, the initial monitoring program has been developed to characterize movement in and around these site-specific locations.

6.3.3.1 Program Design and Methodology

The program is designed to characterize effects of initial development of the tracts and to provide a basis for extended monitoring into Phases II and III. The specific equipment or methods described are considered preliminary. Final determinations will be established in consultation with the AOSS when detailed engineering designs for Phase I are finalized. The program will be modified as necessary, depending on actual construction and disposal activities.

Techniques. Prior to any disposal of processed shale, a series of collectors will be established at the base of the pile to capture any leachate that may percolate through the pile. The leachate collectors will consist of small rectangular plastic-lined concrete boxes filled with pea-sized gravel. The collectors will be drained by 2-inch PVC pipelines to the edge of the pile. The volume of leachate captured by the collectors will be determined and a sample obtained. The leachate sample will be analyzed for the parameters listed in Table 6.3-6. DOC fractionation will initially be analyzed for all samples.

Additional instruments used to monitor water within the pile will be installed at two locations in the central portion of the pile. These instruments include salinity sensors, high pressure lysimeters, and tensiometers. Water samples will be collected from the lysimeters (if any water is available) and will be analyzed for the parameters listed in Table 6.3-6. DOC fractionation will initially be analyzed for all samples.

Salinity sensors, tensiometers, and lysimeters will be installed at various depth intervals. Precautions will be taken so that the instruments will not be disturbed during the filling operation.

The program for the process area will monitor water within the uppermost portion of the modified vadose zone adjacent to certain process-related facilities. It will involve combinations of lysimeters, tensiometers, and salinity sensors installed at the following locations:

- Upgradient of the upper embankment for the shale fines storage area
- Downgradient of the lower embankment for the shale fines storage area
- Upgradient of the wastewater holding basin and downgradient of the tankage area

- Downgradient of the wastewater holding basin

- Immediately downgradient of the raw shale storage area

Frequency. Tensiometer and salinity sensor values will be recorded quarterly, and lysimeters will be sampled quarterly. It may be necessary to collect a composite sample from a lysimeter over several days if there is a limited amount of water available.

The moisture monitoring program results will be evaluated annually to assess the need for modifications to the frequency and/or scope of the monitoring program.

6.3.3.2 Program Rationale

The moisture monitoring program has been developed to characterize changes in the vadose zone that are related to project development. The program is expected to characterize potential leachate contributions of the processed shale pile to the indigenous vadose zone and the movement of any leachate through the pile. It is also expected to characterize any unintended releases of wastewater or leachate from the process area facilities. The acquired data from the Phase I monitoring program will be used to design a monitoring program for Phases II and III.

6.3.4 SPECIAL STUDIES

The sediment and bed material of the surface drainages for the tracts requires special study. One objective of such a study would be to determine the changes in the physical and chemical characteristics of stream sediments during the predevelopment and development periods of the project.

This work would initially consist of examining and analyzing:

- Grain size

- Minerology

- X-ray diffraction
- Spectroscopy, for adsorbed metals
- Adsorbed organic materials
- Cation exchange capacity

These laboratory analyses would initially be performed once a year during low-flow conditions at the following gauging stations:

- White River: 09306395, 09306700
- Evacuation Creek: 09306420, 09306430
- Southam Canyon: 09306605, 09306610
- Asphalt Wash: 09306625
- Plant site drainage: proposed station below plant site

Details of this study will be determined after consultation with the AOSS. It is expected that investigation of the sediment and bed material will be coordinated with detailed water quality analyses when possible.

Characteristics of the processed shale produced during Phase I will also require investigation (see Section 3.10.2). No other areas requiring special emphasis have been identified at this time.

6.3.5 DATA TREATMENT

6.3.5.1 Data Reduction

The data from continuous records of stage, temperature, specific conductance, precipitation, and water level (of wells) will be recorded on punch tape at the monitoring station. Stage records at certain stations will have backup records on strip charts. These data tapes will be reduced and analyzed with computer programs.

Other field monitoring data will be tabulated in an appropriate manner; this includes the period measurement of stream discharge, pH, dissolved oxygen, temperature, specific conductance, suspended sediment concentration, and water level. Following technical review, these values will be incorporated into the final records.

The laboratory water quality data are stored within the U.S. Geological Survey computer system and can be retrieved easily at any time for later analysis.

All raw and final WRSP data records will be kept current and held in a central repository at the WRSP office in Vernal, Utah for possible review or analysis. Hard copy of the U.S. Geological Survey water quality records will also be held in this repository.

6.3.5.2 Data Analysis

Data collected by the water monitoring program will be analyzed to answer the following questions:

1. Are there any significant differences in the physical parameters of the surface or groundwater measured at each station between the predevelopment period and the development period?

2. Are there any significant differences in the chemical composition of the surface or groundwater measured at each station between the predevelopment period and the development period?

3. Does the current monitoring information indicate any significant changes in the relationships between upstream and downstream (or upgradient and downgradient for groundwater) monitoring stations, as defined by the previously collected information?

Preliminary evaluation of the data at each station will begin with appropriate tables and graphs that compare the current information with previously collection information. Such comparisons will show those data

populations that seem to illustrate trends caused by project activities or that require further analysis and interpretation.

The next step in the data evaluation is to separate natural trends from project-related trends or variations. To do this, it will be necessary to estimate the degree of natural variation at each station for a particular point in time, given the climatological conditions before and at that time. Statistical analyses performed in the past have not adequately defined natural fluctuations for certain stations (most notably, the surface water quality of Evacuation Creek and the dry washes during extreme high flow conditions). This is because the period of record is too short to acquire large enough data population to adequately define natural variations, especially under extreme conditions. Statistical analyses using such data populations have had limited value. Every effort will be made to collect additional information from these stations during the earliest stage of development, so that the natural variability can be defined adequately. As new data are collected from control stations not affected by project activities, the statistical analyses will be refined to improve the definition of natural variations. These efforts will involve testing to determine the most representative distribution of data and the appropriate transformations to be applied to the data in order to define the probability density function.

After natural variations at each station have been defined as well as possible, data from the development period will be tested to see if measured values are outside of expected ranges. This will be done using an analysis-of-variance approach with F tests at the 90 percent confidence level. When a test failure occurs, the data will be rechecked for instrument or human error, and for inappropriate grouping or selection of data used in the test.

Evaluation of test failures will then proceed to a comparison of the observed variations at a station with the characterization of potential project related pollutants. The purpose of this comparison is to see whether the variation or trend at a station is the result of project activities. If it is, the contingency plan will be implemented. If the determination is inconclusive, alternative questions will be posed and additional studies will be performed so that the cause of the trend or variation can be determined. If the variation or trend is unrelated to project activities, the probable cause will be documented along with the rationale.

After answering the first two questions and before implementing the contingency plan and/or additional studies, the last question should be answered regarding differences between upstream and downstream conditions. Data from two or more related stations will be evaluated in a manner similar to data evaluated at a single station between different time periods. In other words, the data groups selected for the stations must represent similar conditions at each station.

If this evaluation indicates that the relationship between related stations has changed due to project activities, the contingency plan will be implemented. If the evaluation is inconclusive, additional studies will be done, if necessary. If the evaluation indicates a change that was not cuased by project activities, the probable cause will be documented along with the backup information used to reach this conclusion. When this occurs, future comparisons between related stations will use the most recent relationship for any analyses of spatial variations.

6.3.5.3 Report Products

A report covering all phases of the water monitoring program will be prepared and submitted annually to the AOSS. Each report will contain data gathered

during that water year (September through October). Data will be presented, summarized, and interpreted. A progress report will be prepared and submitted semi-annually to the AOSS. Any unusual or deviant data trends will be reported to the AOSS in a timely manner.

6.3.5.4 Contingency Plan

Throughout the life of the project, the information being collected will be evaluated to determine whether it is meeting its intended purpose. The monitoring program will be modified as required, following consultation and approval by the AOSS.

When a project-related impact is detected, the situation will be assessed and appropriate control technology will be selected (immediately, if the impact is significant) in consultation with the AOSS.

6.3.6 QUALITY ASSURANCE PROGRAM

Following is a preliminary outline of the quality assurance program for this project. A more definitive breakdown and/or any modification to this program will be reviewed and confirmed with the Area Oil Shale Supervisor at a later date.

1. *Program Review and Planning*

    - *Technical review and establishment of a project plan, including schedules, milestones, qualifications of key personnel, and technical procedures to be used by the project staff*

    - *Preparation and implementation of a project quality assurance plan that includes a schedule of quality assurance events — for example, surveillance of field activities, calibration of equipment, etc.*

    - *Supervision of quality assurance staff and technical reviewers and liaison with the Area Oil Shale Supervisor*

- *Overall coordination and verification of quality-related work*

2. *Technical Reviews*

- *Review and establishment of preventive maintenance procedures for equipment used on the project*

- *Maintenance of a master list of all instruments to be calibrated or standardized*

- *Review and establishment of written calibration/standardization procedures*

- *Review and establishment of procedures for assigning a unique identification number for each instrument needing calibration/standardization*

- *Establishment of history file on each instrument needing calibration/standardization containing:*

  a) *Written calibration procedures*

  b) *A log showing instrument accuracy at receipt, adjustments made, instrument accuracy after adjustments, calibration/standardization date, calibration/standardization due dates, instrument identification, identification of standard(s) used, signature of person performing calibration/standardization, etc.*

  c) *Establishment of traceability of calibration/standardization standard source of N.B.S. or recognized physical constant*

  d) *Review and establishment of procedures for documenting calibration of test equipment*

- *Review and establishment of written procedures for collection, reduction, and analysis of data*

- *Final review and approval of the completeness and technical adequacy of reports*

- *Review and approval of subcontractors (e.g., water analysis laboratory) in accordance with the requirements of the project*

- *Maintenance of a master list of the qualifications of all personnel, subcontractors, and consultants assigned to the project*

3. *Surveillance and Auditing*

   - *Periodic scheduled surveillance of project staff and laboratory testing activities to ensure that tasks are performed according to established procedures and applicable regulatory guides and standards*

   - *Coordination and auditing of project work to verify that work is accomplished according to established plans and procedures and to ensure that sufficient backup information and reference material is obtained and is traceable to technically acceptable sources.*

   - *Audits arranged by the Area Oil Shale Supervisor if required*

4. *Documentation and Control of Records*

   - *Coordination and control of project records to ensure retrievability and traceability*

   - *Use of transmittal letters for all submittals of data and use of incoming and outgoing correspondence logs*

6.4 SOLID WASTE MONITORING

The solid waste monitoring plan is based on requirements of the Federal Oil Shale Lease (Ref. 6-1), the Resource Conservation and Recovery Act (RCRA) (Ref. 6-12), and of the Utah State Code of Solid Waste Disposal Regulations, which are summarized in Section 7 of the Summary of Environmental Regulations and Guidelines (Ref. 6-13). The solid waste disposal plan, including waste sources, types, and quantities expected during all phases of the project, is described in Section 5.3. All non-hazardous solid wastes will be deposited in the processed shale disposal area, some uniformly mixed in processed shale, and some layered. Unrecovered hazardous wastes will be disposed of in an approved site.

6.4.1 MONITORING PARAMETERS AND METHODOLOGY

Records will be kept of disposed wastes. These records will include types and approximate quantities of solid wastes, identification of hazardous wastes, the disposal area being used, and special provisions for chemical wastes. Wastes identified as hazardous will be separated and disposed of at an approved hazardous waste disposal facility.

During commercial operation, wastes from Phases II and III will be inventoried as to type, quantity, and compatibility with existing waste prior to being mixed with the processed shale for disposal. Incompatible or hazardous wastes will be disposed of separately. In addition, a regular program of inspection will be established to ensure that collection, storage, transport, and disposal practices are being carried out in a safe and environmentally acceptable manner.

In the water monitoring program outlined in Section 6.3, surface water and groundwater quality data will be collected that will also be used to assess the changes, if any, in surface water or groundwater quality attributable to solid waste disposal practices.

Air quality monitoring plans (Section 6.2) associated with processed shale disposal will include monitoring near the solid waste disposal area. The initial solid waste landfill will contain a small amount of decomposable wastes. Although gas evolution is not expected to be detectable over the life of the lease, the site will be checked regularly for gas emissions using a hand-held hydrocarbon sensor. If detected, the gases will be sampled and analyzed to determine whether control measures are warranted.

6.4.2 RATIONALE

The solid waste monitoring program is designed to comply with applicable federal and state regulations and to ensure that disposal practices are safe and environmentally acceptable. In addition, the monitoring data collection program provides information with which to assess the environmental impacts of the waste disposal operations and the need for implementing additional mitigating measures.

6.4.3 DATA HANDLING

The reporting procedure and the report format, content, and frequency will be subject to the requirements of the Area Oil Shale Supervisor, RCRA, and the Utah State Division of Health.

An annual report will be submitted to the Area Oil Shale Supervisor, EPA, and/or the Utah State Division of Health. The report will summarize the waste disposal operations, will show the location of the disposal site(s), and will identify any major problems or difficulties. Types and approximate quantities of solid wastes disposed of during the reporting period will be tabulated. Water and air quality monitoring data pertinent to solid waste disposal activities will be tabulated and appended to the report.

In addition, required reports describing hazardous waste activity will be submitted to the authorized agency, either the EPA or the Utah State

Department of Health. These reports will contain information relating to the type of hazardous waste received, the quantity of waste, the type of treatments used, the location of the disposed waste, and pertinent water quality monitoring data.

The records kept by WRSP will be available for inspection. Upon completion of a landfill site, a report will be submitted that describes the quantity and general types of wastes, depth of fill, and final cover and rehabilitation steps taken.

6.5 NOISE MONITORING

Although there are no federal or Utah state regulations governing community noise levels, criteria and guidelines have been promulgated by several federal organizations. These are summarized in Section 4 of Reference 6-13.

Since there are no existing communities close to the White River Shale Project, noise impact from construction and operation of the project is expected to be negligible. If communities are developed outside the lease area, compliance with the federal noise level criteria will be necessary at these locations. Wild animals now using the lease lands are shy and are expected to be displaced from areas of human activity with its attendant noise. To provide a record of changes in ambient noise levels from conditions existing prior to development of the lease land, the following monitoring program is proposed.

6.5.1 MONITORING PARAMETERS

The parameters used for monitoring and assessing ambient noise include:

- Sound pressure level (SPL) — used to express the loudness of a sound, measured in dB
- A-weighted SPL — used to describe the magnitude of sounds in terms of human aural response, measured in dBA
- Cumulative distribution level (L_n) — the A-weighted SPL in dBA exceeded for a given percentage of the time, denoted by the subscript n
- Equivalent sound level (L_{eq}) — the A-weighted steady noise level that, in a stated period of time, contains the equivalent amount of noise energy as the time-varying noise during the same period
- Day-night sound level (L_{dn}) — the equivalent A-weighted sound level during a 24-hour time period with a 10-decibel weighting applied to the equivalent sound level during the nighttime hours of 10 p.m. to 7 a.m.

6.5.2 MONITORING METHODOLOGY

6.5.2.1 Sampling Equipment and Techniques

The ambient noise will be recorded by digital or analog recorder with a sound measuring system that meets ANSI standards for Type 1 sound level meters (Ref. 6-14). The device will record A-weighted levels measured in the "Slow" meter response mode; it will sample the ambient noise at a minimum rate of once per second over the entire monitoring period; and it will be designed and packaged so that it is unaffected by outdoor exposure for a minimum of 24 hours.

The recorder will be set up at the monitoring location and calibrated prior to operation. The unattended recorder will monitor and record noise levels for at least 24 hours in each location, and will be recalibrated at the end of the monitoring period. The instrumentation and measurement techniques will follow ANSI guidelines for measurement of sound pressure levels in outdoor environments (Ref. 6-15). In addition, provisions will be made for measuring wind speed at the monitoring locations.

6.5.2.2 Sampling Locations and Frequency

To monitor the major types of activity on the lease tracts, two monitoring stations will be used. The first station will be north of the main process area, and will coincide with the closest northern boundary line. The second station will be south of the processed shale disposal area at the intersection of the existing access road and the southernmost boundary line of the tract. (See Figure 6.2-1 for location.)

Both stations will be at the same or greater elevation than the main processing area and will be greater than 100 feet from the access roads. These stations will be used throughout the monitoring program. Recordings

will be obtained for 2 days (two 24-hour periods) at each location during each of the following phases of the White River Shale Project:

- Before construction
- Phase I
  - Construction, earth moving stage
  - Full capacity operation
- Phase II
  - Construction, earth moving stage
  - Full capacity operation
- Phase III
  - Construction, earth moving stage (and simultaneous full capacity operation of Phase II)
  - Full capacity operation

None of these measurements should be made during "extraordinary" events or situations (such as road building near the monitoring sites), since these events would render the monitoring periods atypical of the phases of construction and operation.

6.5.3 RATIONALE

The monitoring program is designed to provide a historical record of the present noise environment and the noise environment during construction and operation of the project. The data can also be applied to land-use planning in the vicinity of the lease tracts.

The dBA is widely employed to describe the magnitude of environmental noise. A-weighting, standardized in current sound level meter specifications, correlates well with human response to noise. L_{eq}'s and L_{dn}'s have been used by the EPA to define safe levels of noise (Ref. 6-16).

In a comprehensive program for monitoring noise, samples will be taken of the area to arrive at a numerical representation of a noise environment, and the time-varying noise level during an entire day must be recorded and analyzed. The technique that uses each 24-hour period as a standard of comparison has been widely employed and is described in noise surveys and studies (Ref. 6-17).

The plant site is remote; the closest community is Bonanza, approximately 5 miles from the northern tract boundary. Owing to sound attenuation with distance and to natural barriers imposed by the terrain, monitoring the noise at the nearest community is not expected to reveal the impact of noise generated by construction or operation of the project. Monitoring the noise close to the plant site will provide a better description of noise impact on the surrounding area, as it will accurately reflect changes in the localized ambient noise environment due to construction and operation. The 2-day monitoring periods are designed to describe a reasonable, long-term worst-case noise environment during these phases.

6.5.4 DATA HANDLING

The data for each location will be compiled in a report for each 2-day monitoring period and will include the 24-hour L_{eq}'s, L_{dn}'s, and L_n's. In addition, histograms depicting the L_1, L_{10}, L_{50}, L_{90}, L_{99} levels and average wind speed at each location will be furnished. The data will be compared with EPA noise criteria (Ref. 6-16). Applicable portions of ANSI S1. 13-1971 (Ref. 6-15) will be used in reporting sound level data. Data showing a project-long histogram of the noise environment at each location will be available.

6.6 BIOTA MONITORING

6.6.1 PROGRAM DESIGN RATIONALE

The primary impacts of oil shale development on the biota of Tracts Ua and Ub are expected to occur as a result of:

- Surface disturbance by site preparation, road and corridor construction, and shale disposal
- Noise and high levels of activity
- Air emissions and dust
- Potential leaching of compounds into surface and subsurface water
- Changes in abundances and diversities of species due to habitat disturbance/enhancement programs

The Area Oil Shale Supervisors Office (AOSS), in Guidelines for Monitoring the Environmental Effects of Development on the Federal Prototype Lease Tracts (Ref. 6-18), indicates that a primary goal of the Federal Prototype Oil Shale Leasing Program is, "to insure the environmental integrity of the affected areas and at the same time develop a full range of environmental safeguards and restoration techniques that will be incorporated into the planning of a mature oil shale industry, should one develop." The Oil Shale Lease Environmental Stipulations require the lessees to conduct a monitoring program before, during, and subsequent to development operations.

To achieve these goals, AOSS published a set of guidelines for developing monitoring programs. The guidelines appropriate to this section of the DDP are addressed in terms of biota monitoring:

- *Describe existing environmental conditions.* (These are discussed in Section 2.5, Biological Resources.)
- *Identify candidate potential parameters to monitor during the initial development phase.* The monitoring parameters have been selected based on the findings of the baseline and interim monitoring programs, AOSS guideline matrix,

and the expected effects of the proposed action. (Discussed in Section 5.4.)

- *Select potential parameters to monitor based on likelihood of impact, degree of impact, importance, legal requirements, measurability, interpretability, and cost effectiveness.* Parameters were selected for these reasons and because they will aid in establishing a flexible, comprehensive monitoring program.

- *Design statistical procedures for detecting and evaluating degree of impact.* (Discussed in Section 6.6.2.)

- *Develop a quality assurance program.* (Discussed in Section 6.6.3.)

- *Build into a computer program appropriate threshold values for specific parameters.* (Discussed in Section 6.6.4.)

- *Design a contingency plan.*

In addition, parameters for monitoring were selected because of the following attributes:

- Flexibility — data could be used to evaluate more than one impact.

- Ecosystem oriented data — could be used in conjunction with abiotic monitoring parameters, and general ecological patterns could be determined that would be useful in evaluating other oil shale developments.

- Site specificity — data are specific for Tracts Ua and Ub, but they could also be used in a regional context.

- Availability of background data — parameters studied in the baseline and interim programs have a high priority, but additional parameters were added when needed.

The purpose of the biota monitoring program is to assess the impacts of surface disturbance and pollutants on the organisms of the oil shale tracts. Data gathered in the monitoring program will be incorporated into the continuing refinement of the ecosystem model for the tracts. With this approach, the number of parameters measured can be reduced as appropriate relationships are quantified. The intensity of sampling can then

be determined by the importance or relevance to perturbations. Those parameters that have quantified relationships with other more important parameters can then be dropped from continuous monitoring, as well as those that show limited relevance. Information will be incorporated into the contingency plan and used to solve problems as they arise. Thus, as the model is refined during monitoring, the scope and cost of the monitoring program can be reduced.

By fully evaluating the effects of oil shale development in the prototype program, a case history is developed. Such a history will be useful in evaluating effects of future synfuel developments in the Uinta Basin and elsewhere.

An annual report will be prepared covering all aspects of the biota monitoring program. For convenience, separate reports for vegetation, wildlife, and aquatics will be prepared. Where appropriate, data will be integrated to show interrelationships. Statistical parameters will be calculated to indicate the range of variability, degree of correlation, and statistical reliability.

6.6.2 MONITORING PARAMETERS

Monitoring of the biota will be coordinated both spatially and temporally with air and water monitoring programs. Insofar as possible, vegetation, animal, and microbiological sampling will be scheduled within the same time periods and at the same or representative field locations.

The biota monitoring program will, where possible, continue to use the sampling areas established in the baseline study, many of which have served for joint flora and fauna sampling activities since 1975. Sampling sites from the baseline study that are eliminated by facilities development will be replaced by ecologically comparable sites.

Several offsite (control) sampling areas may be established to compare areas within the perturbation influence of oil shale development to areas where such influence is expected to be negligible. These areas will be chosen for their similarity to on-tract sampling areas most likely to receive the highest perturbation levels.

The monitoring program for the terrestrial and aquatic subsystems is described below.

6.6.2.1 Terrestrial Subsystem

Flora. The four vegetation types on Tracts Ua and Ub serve several purposes: wildlife habitat, watershed (soil) cover, livestock forage, and giving natural beauty to the physical landscape. The effective functioning of this flora is the key to the viability of the arid ecosystems that exist on the oil shale tracts. A monitoring program is important to adequately determine the environmental affects of oil shale development and operations on this vegetation. Most of the parameters to be monitored are those that were assessed in the baseline inventory, and subsequently continued at an appropriately reduced level of activity.

Expected project impacts on the vegetation are surface disturbance, increased wildlife population density, dust and particulates, gaseous emissions, soil erosion, and runoff. Plant responses to these perturbations may or may not be significant, depending on the ability of the plants to adjust to the level of perturbation in given areas where disturbance is the most intense.

Vegetation parameters to be monitored include:

- Biomass production of annual plants
- Sagebrush stem leader growth (a measure of shrub productivity)
- Chemical concentrations by plants

- Plant utilization by animals
- Plant condition and stress

Most of these will be monitored on the sampling areas used in the baseline study, but some will be measured in relation to rehabilitation plantings on processed shale and disturbed sites. The monitoring program is based on the likelihood of an impact, the significance of impacts to the parameter, the design of the monitoring program, and the use of the data collected in a computer program to assess the overall relationship of that parameter to the ecosystem of the tracts and the region in general.

Biomass production by annual plant species. The abundance (productivity) of annual plant species is important, since it provides food and shelter for large and small animals, ground cover in the vegetative stage, and litter that prevents soil surface erosion and recycles nutrients. The likelihood of an impact on annual vegetation production from air pollutants, surface disturbance, increased wildlife activity, and surface erosion is high. It is relatively easy to measure annual aboveground biomass production by clipping and weighing samples from each vegetation type.

Previously, the monitoring program involved clipping 100 .25 m^2 plots in each vegetation type. This level of sampling intensity will be continued, because there is great variability in production from year to year among vegetation types and within sites.

The variability among years has been so great that the value of the data for use in predictive or causal relationships is reduced. Subsequent to the start of retort operations, a paired-plot sampling design may be followed using off-tract sampling areas and existing shadscale and sagebrush-greasewood vegetation sites in conjunction with air and water monitoring stations. Riparian vegetation will be included if construction of the White River Dam and Reservoir is delayed. Juniper vegetation will be omitted because it has very little understory annual

plant species. Thus, the sampling program will involve clipping, drying, and weighing the aboveground biomass of annual plant species from 20 plots, .25 m^2 in each sampling location, on tract and off tract, in the shadscale and sagebrush-greasewood vegetation types. Plots will be clipped each spring at the peak of production.

A suitable design for statistical analysis will be used to determine differences in annual plant productivity between vegetation types, among sampling areas and within vegetation types, and development effects measured by on-tract versus off-tract plant productivity.

Data from the monitoring program will be used to correlate animal population numbers with climatic variables.

Sagebrush stem growth measurement. On the basis of professional experience and measurements for the past 5 years, new stem growth in shrubs appears to be very responsive to different degrees of environmental favorability. Sagebrush stems begin growth in early spring and do not cease growth until late fall; during that time they are exposed to drought, high temperature, and other factors controlling growth. Because of this long seasonal exposure time and relatively high responses to environmental extremes (see Figure 2.5-10), sagebrush stems have a high likelihood of being affected by development impacts.

The ecological significance of sagebrush leader growth is high, since it reflects conditions also imposed on other shrubs and perennial species. Because of the widespread occurrence of sagebrush on Tracts Ua and Ub, any responses observed in its growth represent conditions over an extensive area. Sagebrush is not of high economic importance as a browse species, but it is valuable for its contribution to wildlife habitat and watershed cover. It has a high value as an index of site conditions and as a representative of other vegetation components. Sagebrush productivity is representative of the mean shrub productivity on the tracts and it is

thus a good indicator of overall shrub production. Another aspect favoring sagebrush leader length as an index is the repeatability, ease, and accuracy of stem measurement.

The monitoring design to be used is a continuation of a sampling program followed for the past 6 years. Procedures are outlined in the Final Baseline Report (Ref. 6-3) and consist of measuring 20 stems (the longest stem in a small group of stems) on 20 plants at each sampling site. Leader growth will also be sampled on the wildlife transects to facilitate the comparison of shrub productivity with animal abundance and diversity. A suitable statistical design will be used to test whether the air quality near the industrial site has any effect on sagebrush leader growth. The analysis would also test for significance among the years of variable weather conditions as separate influences from the general impacts of industrial development.

Data from this study will be useful in correlating plant responses to perturbations caused by air pollution and altered surface runoff.

Animal use of plants. Plants are affected by increased grazing pressures resulting from reduction of habitat area. They may also be affected by changes in animal use as a result of decreased plant health or shift in palatability.

Animal use of plants has considerable ecological and economic importance. If plants are in a less vigorous state as a result of purturbations from oil shale development, the likelihood of damage to plants from animal use is considerably increased compared with non-affected plants. Loss of plant vigor in key species could result in changes in composition that would trigger a further decline in ecosystem productivity and range condition. The perennial shrubs are the dominant and abundant plants on the tracts, and are the most likely to be impacted by animal use.

Two types of animal use will be monitored: 1) grazing by big game and livestock and 2) use by small mammals and invertebrates. To monitor such divergent use patterns, two sampling approaches will be used at the sampling sites established in each vegetation type during the baseline inventory. In addition, a range condition analysis will be conducted yearly.

Big game and livestock graze primarily on young twigs (stems) and leaves; use by these animals will be monitored by counting the browsed ends of twigs on randomly selected key species (Ref. 6-19). The number of plants required of each species for statistical adequacy will be determined in a preliminary field test. Species that will be monitored for animal use include *Artemisia tridentata, Atriplex confirtifolia, Atriplex cuneata, Chrysothamnus greenii,* and *Sarcobatus vermiculatus.*

Small animal and invertebrate use of vegetation will be monitored by an ocular estimate of percent of leaf use and presence of leaf-eating vertebrates. The ocular estimates will employ a simple 5-scale rating system applied to the five above-named shrubs in plots on sagebrush-greasewood and shadscale vegetation types both on and off the tracts. The main objective of this second monitoring activity is to quantify and systematize observations of plant use other than browsing.

To assess the general condition of the vegetation (in the sense used by range conservationists), an annual assessment of range conditions will be made in September based on standard methodology used by the Bureau of Land Management and range technicians in general (Refs. 6-20 and 6-21). On-tract range conditions will be compared to those off tract.

The measures of animal use and range condition will permit correlation with animal population density changes. Further, by monitoring animal use, a check on the results of wildlife and livestock management practices is possible.

Chemical concentrations in plants. When chemical concentrations in the air or soil (or plant growth substrate such as processed shale) are higher than normal, there is a possibility that plants will take up such chemicals, sometimes in excess. Gaseous effluents from retorting operations and salts and heavy metals contained in leachate from processed shale may also be available for plant uptake.

Clean air and water standards require that levels of effluents be kept within legal limits, but plants may extract and concentrate chemicals to levels that may be deleterious to plant or animal life when they are concentrated ecologically. For example, when annual bluegrass (*Poa annual*) is subjected to air pollutants in southern California, it shows leaf tip burn and reduced growth and is thus used as a visual index for reduced air quality. Chemical concentrations should be monitored to check for such effects. Monitoring of these parameters would occur in the year following initiation of retort operations.

Clearly, any major changes in plant density or composition as a result of adverse effects on the vegetation could have serious consequences in altering wildlife habitat carrying capacity, watershed ground cover, and animal populations. Measurement of chemical concentrations in excess amounts in plant tissues is relatively easy to accomplish with precision using standard laboratory analyses. Reference plant samples must be taken in proper relationship to the source of effluents or leachate to provide valid comparisons.

Plant samples for chemical analysis will be obtained from three sampling areas:

- Spaced locations at incremental distances from the shale processing facilities
- Typical rehabilitation planting of species growing on the processed shale disposal pile
- A control sampling at an off-tract location free of shale processing influences

The final design of this monitoring effort will be determined from preliminary data relative to variability of plant response differences in species uptake of chemicals, and appropriate time for sample collection. At the outset, replicated samples will be taken in May or October from two shrubs (*Artemisia tridentata* and *Grayia Brandegei*), two grasses (*Bromus tectorum* and *Oryzopsis hymenoides*), and two forbs (*Hedysarum boreale* and *Salsola Kali*). In each group, one of the species matures early and the other matures late. Plant materials or current season litter will be prepared for standard laboratory analysis (Ref. 6-22) for the following parameters: SO_4, NO_3-N, Na, Ca, K, Mg, B, Cd, Zn, As, Hg, Pb, Ni, F, Fe, Se, and any other elements that appear to be a potential hazard. The number of chemicals will be reduced if a consistent pattern of no difference is evident between affected sampling areas and controls.

Data obtained from the chemical analyses will be used in the system model to assess relationships among plant and animal responses and ecosystems functioning. Weather variables and soil factors will be correlated with concentration of pollutants in air and soil.

Plant condition and stress. Perturbations from oil shale development may cause stress to plants and reduce their vigor. Plants may respond to stress visually or temporally, but many responses may only be detected with instruments.

Plant condition is an early warning of change. Maintaining good plant vigor and minimizing stress from perturbations is ecologically desirable. Maintaining or increasing productivity to sustain the numbers and kinds of wildlife that exist on the tracts is important to the wildlife management plan and to the ranchers who graze livestock on the tracts. Monitoring can detect any significant changes in plant condition or stress as reflected in retarded pheological development, deviations from average leaf color and size, leaf necrosis, and reduced seed production.

The monitoring program will concentrate on plants growing in the vicinity of the industrial site, revegetation species on the proposed shale disposal pile, and an off-site control areas of similar plant species. Principal species will be observed in established sampling sites in the three locations described above. A numerical rating system or actual measurements will be used in rating visual responses rather than using descriptive terms (see Table 6.6-1).

Table 6.6-1

MONITORING PARAMETERS OF PLANT CONDITION AND STRESS

Parameter Measured	Measurement Method	Time of Sampling		
		May	June	October
Phenological Stage[a]	Rating Scale of 1 to 10	X	X	X
Leaf Color	Using Munsel Color Chart	X	X	X
Leaf Size	Average length of largest leaf, 10 per plant	X	X	
Leaf Necrosis	Percent affected		X	X
Seed Production	Number of seeds per seed stalk		X	X

(a) See methodology described in Baseline Inventory (Ref. 6-3).

Ten plants of each species will be monitored in each sampling location and will be permanently identified with aluminum tags. In addition to the visual ratings of plant stress, plant samples will be obtained for instrument or laboratory screening of stress responses. Leaf water potential and chlorophyll A will be determined on representative samples.

Plants under different conditions could be compared: 1) plants under air quality perturbation versus control plants and 2) plants growing on processed shale or a mix of soil and shale versus control plants.

Microbiology and Soils. The biochemical activities of microorganisms are of primary importance in the decomposition of detritus and litter and in the replenishment of the nutrient supply needed by the plant community. If these processes are slowed or halted, plant growth is reduced or stopped.

Soil microbes are sensitive to environmental pollution, especially in arid areas. Toxic substances released into the air or water from the retort plant or disposal pile may accumulate in the soil and decrease the biomass or biochemical activity in the soil. Decreased activity could eventually result in changes in the plant community (productivity, cover, and composition). These changes will be noted in the vegetation monitoring. Time will be required, however, for changes in vegetation to occur and the soil microbiology could be irreversibly altered by that time. It is necessary, therefore, to measure soil chemistry and biochemical activity directly in order to have an early warning of possible impacts of the oil shale operation on plant and animal communities.

The parameters to be monitored include soil chemistry, microbial activity, and cryptogamic crusts and lichens; measurement will be more intensive on the processed shale disposal site. Monitoring of these three parameters will occur in the year following initiation of retort operations.

Soil chemistry. Section 5.4 lists the toxic elements that may be present in water leached from the processed shale or in emissions from the retort plant or that accumulate in the soil. Chemical analyses by standard methods will be performed to determine concentrations of these substances. In addition, reaction (pH) and electrical conductivity will be measured.

Microbial activity. Soil microbial activity will be monitored by measuring respiration, dehydrogenase activity, and ATP concentration using methodologies described in the First Year Environmental Baseline Report (Ref. 6-2). Respiration measures the total metabolic rate for the microbial community; dehydrogenase activity is an index of decomposition of

organic matter in the soil; and ATP is a measure of the total biomass of microbial organisms. These parameters were found in the baseline study to fluctuate widely with changes in temperature, organic carbon, total nitrogen, and soil moisture. Therefore, these effects must be accounted for before possible changes resulting from the shale operations can be observed. To do this, soil temperature, organic carbon, total nitrogen, and moisture will be measured concurrently with respiration, dehydrogenase, and ATP. Using regression equations that have been developed from data in the baseline study, predicted values of respiration, dehydrogenase, and ATP will be calculated.

If the measured values are significantly lower than predicted values, and if soil analysis indicates high concentrations of toxic substances, there may be toxicity effects involved and a more careful analysis of the situation should be performed. Conversely, if no differences are found between sites influenced by development and locations relatively free from development impacts, the monitoring program wwould cease.

Cryptogamic crusts and lichens. Cryptogamic crusts are important in reducing erosion and increasing soil fertility. Because cryptogams are particularly sensitive to air pollutants, these organisms should be monitored and could prove to be a good early-warning system. The condition of the crusts is difficult to monitor directly because the crusts are easily disturbed. However, lichens, which are closely related to algal crusts and respond to the same perturbations, are easily monitored because they occur on rocks; this makes observations of individuals possible from year to year.

Areas of lichen monitoring will be established on or near the vegetation and soil sampling sites. Thalus growth and condition will be measured in conjunction with this sampling.

Lichen parameters will be measured in April, June, and October to coincide with the measurements of vegetation and wildlife. Samples will be taken from under the shrub canopy and in the interspaces at each sampling site (the same sites used for vegetation sampling), since significant differences were found in the Baseline Report between canopy and interspace activities. Paramaters at each site will be measured concurrently so that meaningful relationships can be established. Paired samples will be taken on and off tract. Sampling methods, sample numbers, and statistical procedures will be described in detail in the monitoring manual, as discussed in Section 6.6.5.

Processed shale disposal site. Salinity and moisture measurements within the root zone on the shale disposal piles will be made in May and October. The bare shale water-harvesting surfaces will be monitored to determine rates of change in pH, EC, and soil microbial activity, which will be the deciding factors in how rapidly vegetation will become established on these areas. The planting trenches will also be monitored for changes in EC, microbial activity, pH, and toxic substances that could result from those substances being carried and concentrated by harvested runoff. Increases in salt concentrations could be a major problem, so EC will be measured at the surface and at 10 centimeter depth intervals to determine patterns of salt movement.

In addition, moisture in the main body of the shale pile will be monitored to determine if and at what rate water is percolating past the reach of the plant roots and into the main body of the shale pile. Replicated measurements will be taken by lowering a neutron probe through a pipe in a hold bored 30 feet or more into the shale pile. These measurements need to be taken only once a year, because any changes in the depth of the wetting front will occur slowly.

Fauna. Terrestrial vertebrates will be monitored to follow population changes in relations to wildlife habitat quality and intensity of disturbance. Rodents and small game are important consumers of plant materials and they in turn provide a bood base for raptors and other predators.

Mule deer are sensitive to disturbance and are of recreational and economic importance. Wildlife data correlate well with vegetation and climatic parameters; and with appropriate methods, wildlife parameters are suitable for ecosystem monitoring.

Wildlife surveys will be conducted on 1 kilometer line transects as in the baseline and interim monitoring programs (Refs. 6-3 and 6-23). These transects will provide data on species composition and abundance of birds, mammals, and reptiles. Sampling trips will be initiated approximately 1/2 hour after sunrise and usually completed within 2 hours. Data taken during baseline and interim monitoring indicate that wildlife species are not limited to a given vegetation type. Each transect represents a replicate for Tracts Ua and Ub.

Transects will be located to best monitor the effects of development and of the mitigation programs. Tentative locations are as follows:

- WG-3 in Asphalt Wash to provide data on the mitigation program and as a control area that is relatively isolated from the development
- WG-2 in Southam Canyon to provide data on the effects of processed shale disposal
- WJ-4 in the southern uplands to provide data on the effects of the processing facilities
- WS-1 in the eastern portion of Ub to provide data on the mitigation program and as a control area that is relatively isolated from the development
- WS-4 in the northwest corner of Ub to provide data on the effects of the access road, water pipeline, and powerline corridor

- WR-2 to monitor the riparian area if the White River Dam is not built

- Offsite sampling, in conjunction with vegetation sampling sites that were established to replace sites eliminated by development

Rodents will be sampled by trapping, as in the baseline and interim programs. Rodents are important primary consumers of plant materials. Because of this, they could affect the revegetation program. Since rodents form a food base for most of the mammalian, avian, and reptilian predators, the natural population cycles of many of these predators may be related to fluctuations in the rodent populations. The ecological significance of rodents, together with the availability of relatively good quantitative techniques and large amounts of background data, make this a suitable group to monitor.

The primary impacts of development to rodents will be surface disturbance. Indirect effects due to pollutants are expected. Locations for sampling will be the same as the wildlife transects. In addition, the revegetation areas will be sampled to ascertain the effects of the rodents on the establishment of plants and to measure effectiveness of revegetation for wildlife habitat.

The following parameters will be measured, as in the baseline and interim monitoring programs:

- Species
- Numbers
- Sex
- Age
- Body condition
- Nipple condition

- Testicular condition
- Habitat
- Time of year
- Trap location

Transect surveys and rodent trapping will be conducted in April, June, August, and October during the initial year of expanded monitoring, and will be reduced during subsequent years. Statistical analysis of 6 years of data for the tracts indicates that these are the most important seasons. April data indicate how the vertebrate populations survived the winter; June and August data indicate reproductive success and activity during the peak of the growing season; and October data indicate the condition of the populations after summer drought and before winter.

Deer are sensitive to disturbances by man and are of recreational and economic importance. In addition to transect surveys, standardized aerial counts will be conducted. Flights will cover the tracts and the 1 mile perimeter of the tracts on three consecutive days each winter (December-January), preferably during periods of light snow cover. The transects will be flown at approximately 1/2 mile intervals and at a constant altitude. Two experienced observers and the pilot will count deer on each transect and record their location. Sex, age, activity, and other pertinent factors will be noted wherever possible.

Terrestrial invertebrates. Species composition and population dynamics of terrestrial invertebrates have been included with this program for the following reasons:

- They are the most important consumers of primary production in terrestrial ecosystems
- Ecological research has indicated that statistically adequate data can be obtained when sampling is restricted to particular insect groups or substrate types

- Data collected would be extremely useful in assessing effects on primary production, the food base for vertebrates, and bioaccumulation of toxic compounds if they appear in the plants (a contingency plan)

- Data on invertebrates is especially important for evaluating bird species composition and population dynamics. Until these relationships are established, indirect monitoring of this component, as suggested previously, is impossible

The invertebrate component is likely to be affected by surface disturbance and by pollutants. They are likely to undergo changes in species composition and abundance. In addition, these parameters are also affected by climate. Changes will in turn affect insectivorous vertebrates. If the appropriate relationships are not understood, changes in vertebrate populations cannot be attributed solely to natural causes; i.e., industrial effects can be implied when they may not be involved.

The invertebrate sampling is not intended to be continued through the entire life of the operation. It is intended to continue only as long as needed to establish the relationships in the ecosystem model.

Commonly used sampling methods will be used to assess invertebrate production with respect to plant production (Ref. 6-19). Invertebrates will be sampled with a suction apparatus, similar to a "D-Vac" sampler, on *Artemisia tridentata* and other shrub species, if necessary. Sampling locations will correspond with the plant sampling sites. Sampling of the invertebrates will occur in June during their season of peak activity.

Bioaccumulation of toxic compounds. If plants are found to accumulate toxic chemicals, a contingency plan for determining bioaccumulation in rodents and grasshoppers may be initiated. These animals are important links in the terrestrial food chain, so bioaccumulation of toxic

compounds at this trophic level could affect secondary consumers. At initiation of monitoring, samples of body fat from rodents in the different transects will be analyzed for background levels of trace metals and other potentially toxic compounds associated with oil shale development.

Initial samples of grasshoppers, the most important grazer of vegetation, will be analyzed for trace metals and other potentially toxic compounds associated with oil shale development. These levels will be used as a basis for comparison to judge the effects of bioaccumulation. This work will be conducted at a more intensive level initially than is intended for long-range monitoring. Once the ecological relationships necessary to guide monitoring are established, the program will be reduced, with approval of the AOSS, to measure only the important parameters of the model.

6.6.2.2 Aquatic Subsystem

Aquatic monitoring will be coordinated with water quality monitoring temporally and spatially so that the maximum information may be obtained without duplication of effort.

Procedures to be followed in the aquatic sampling program will be those recognized by acknowledged authorities in the field. The methods will be in accordance with References 6-24 through 6-34.

Sampling Locations. The White River and Evacuation Creek, as receiving streams draining the tracts, will be subject to effects from construction and operation on the tracts. These potential effects are discussed in Section 5. Stream monitoring is necessary to see how they are affected, and to document environmental impact, effectiveness of countermeasures, and rate of recovery in the event of accidents or spills.

The ponds constructed on site, as static bodies of water, could accumulate many pollutants to much higher concentrations than the streams. In general, their locations in drainage channels allow them to act as traps for pollutants transported by air and surface runoff. As such, they are excellent "early warning" sites for the transport of potentially damaging compounds to the river system.

The Southam Canyon retention dams, treated water effluent holding pond, and storm water holding pond, as containers of the highest concentrations of leachates and other process-related compounds, offer excellent opportunities to document the ability of organisms to tolerate these compounds. The stock ponds and others will function in this respect to a lesser degree.

Selection of sampling stations will be based on legal requirements and AOSS guidelines. They will be accessible and will be representative of conditions in the whole body of water under consideration. They will reflect information gained during the 2-year baseline period, and they will provide offsite reporting of conditions upstream and downstream of the tracts for the White River. Site locations will be as listed in Table 6.6-2.

Characterization of Habitats. If the White River Dam is significantly delayed, a survey of the aquatic habitat characteristics of the White River and Evacuation Creek will be conducted during baseflow, lower basin runoff, and upper basin runoff. In the White River, the bounds of the survey will be from Hell's Hole Canyon upstream to Asphalt Wash downstream. In Evacuation Creek, the survey will be limited by the White River downstream and the Ignatio Road upstream.

Stream stations will be located at suitable locations determined by onsite analysis. At each station, five transects will be established across the stream perpendicular to flow direction. On each transect at suitable intervals, depth, velocity, and substrate type will be recorded. This

Table 6.6-2

AQUATIC MONITORING SITES

Site No.	Description
White River	
M-1[a]	Upstream of tracts in vicinity of baseline stations F-1, 2
M-2 & 3[a]	Adjacent to tracts in vicinity of baseline stations F-3, 4
M-4	Downstream of tracts in vicinity of baseline station
Evacuation Creek	
M-5	Near baseline station F-6, or above high water level if the White River Dam is constructed
Ponds	
M-6	Southam Canyon Retention Dam, Phase I
M-7	Southam Canyon Retention Dam, Phase II and III
M-8	Freshwater holding pond
M-9	Treated effluent and storm runoff holding pond

(a) These sites will be replaced by an equal number of sites to monitor littoral and pelagic conditions when the White River Dam is constructed.

information will be entered into an in-stream flow computer model used to determine the amounts of different stream habitat available during difficult flow regimes.

Maps will be drawn of each pond habitat, including bottom contours and sample site locations.

Physical Parameters. The parameters shown in Table 6.6-3 will be measured at each sampling site as noted during each sampling period of the intensive

Table 6.6-3

PHYSICAL PARAMETERS OF AQUATIC MONITORING

Parameter	Station Only	Each Site
Evaporation Rate	X	
Photoperiod	X	
Incident Solar Radiation at Water Surface and Substrate		X
Discharge	X	
Temperature		X
Total and Dissolved Suspended Solids	X	
Total and Dissolved Organic Constituents	X	
Depth		X
Water Velocity		X
Substrate Size, Texture, Composition and Stability		X
Turbidity	X	
Conductivity	X	

monitoring period and until model relationships are determined. After that, only the important or driving variables will be measured during long-term monitoring.

Chemical Parameters. The following parameters will be measured at each sampling site during each sampling period. These will be monitored during the initial intensive monitoring period until model relationships are determined. Then only the important or driving variables will be measured during long-term monitoring.

- pH
- Dissolved gases, CO_2, O_2 and H_2S

- Macronutrients
  - Ammonia
  - Nitrate
  - Nitrite
  - Kjeldahl nitrogen
  - Orthophosphate
- Micronutrients
  - Boron
  - Copper
  - Iron
  - Manganese
  - Zinc
  - Cobalt
  - Silica

Trace metals and other compounds known to be potentially harmful to aquatic biota and contained in raw and processed shale will be measured in the water column and sediments annually. These include, at a minimum, cadmium, iron, lead, mercury, nickel, potassium, selenium, silver, sodium, zinc, fluoride, and oils and their derivatives (napthalenes, phenols).

Biotic Parameters. Monitoring of biotic components provides information on the energy flow and the structural and functional characteristics of the aquatic subsystem. Neither structure nor function considered alone can describe the system adequately to allow the effects of oil shale development to be identified.

Biotic parameters will be measured at each sampling site within a station during each sampling period. The organisms to be monitored include periphyton and phytoplankton, bacteria and fungi, macroinvertebrates, and fish. The organic environment will also be monitored.

Periphyton and phytoplankton. As primary producers and important food base organisms for the higher trophic levels, the algae are critical to any aquatic monitoring program. Their fate can, in large part, determine the fate of higher organisms; they can alter production rates, accumulate toxic compounds that might be passed on to consuming organisms, and change species composition. Structural and function parameters necessary to characterize the community are:

- Taxonomic composition and key taxa
- Diversity
- Biomass/density
- Chlorophyll
- ATP
- Gross/net production
- Community respiration (In situ production and respiration measurements should be made on common samples for periphyton, bacteria and fungi, and macroinvertebrates.)
- Production/respiration
- Production/biomass

During initial sampling, selected samples from each stream or pond will be analyzed for trace elements and other compounds associated with oil shale development. This will establish background levels of these compounds for later comparison. After initial phases of monitoring required to establish model relationships, taxonomic analysis will be

dropped in favor of the broader parameters. Samples will be preserved as part of a contingency plan if later taxonomic analysis becomes necessary.

Bacteria and fungi. These organisms are extremely important in nutrient cycling and as food base organisms for higher trophic levels. Their ability to alter (detoxify) or metabolize many compounds that are toxic to higher organisms and their role in energy flow in aquatic systems makes their characterization extremely important. Taxonomic difficulty necessitates reliance on other indirect measures where possible. Important parameters requiring monitoring are:

- Taxonomic composition (and key morphologic groups)
- Diversity
- Biomass
- ATP
- Community respiration (see periphyton and phytoplankton above)

After initial phases of monitoring required to establish model relationships, taxonomic analysis will be dropped in favor of the broader parameters.

Macroinvertebrates. As consumers of microbes, organic matter, and algae, macroinvertebrates are important energy rectors to higher trophic levels. They are candidates for bioaccumulation of toxins and can pass these on to higher organisms, including man. They serve as an important food base for fish and many terrestrial animals. Their ease of sampling and taxonomy make them important elements in a monitoring program where the fishery is technically and legally difficult to characterize, such as in the White River system. Structural and functional parameters necessary to characterize the macroinvertebrate community are:

- Taxonomic composition and key taxa
- Diversity

- Biomass/numbers
- Production
- Functional groups
- Community respiration (see periphyton and phytoplankton above)
- Emergence (During the initial year of monitoring, records of emergence should be kept so that changes in species composition of the benthos during the year may be better explained.)

During initial sampling, selected groups of organisms from each stream or pond should be analyzed for trace elements and other compounds associated with oil shale development. This will establish background levels of these compounds for later comparison as part of contingency planning.

Fish. Legal restrictions relating to harassment of endangered species require that the fishery of the White River be monitored only by public agencies, so it will be left to the responsible agencies to maintain surveillance of the fishery. However, the microbes, algae, and macroinvertebrates will allow conditions within which the fish exist to be continually checked.

Samples of the fish species present will be analyzed by a licensed firm for the content of trace metals and other potentially toxic compounds associated with oil shale development. This information could then be used in the contingency program.

Organic environment. The input of organic matter from the terrestrial system relative to in-situ generation of organic matter through photosynthesis is important as a driving variable that can regulate species composition, trophic dependence, and carrying capacity of the water body. The organic environment must be characterized in order to complete the functional and structural picture of the aquatic system.

Following are the important parameters of the organic environment to be measured for each sampling site during each sampling period:

- Non-living organic biomass within each substrate sample
- ATP
- Suspended organic matter
- Dissolved organic matter
- Terrestrial contribution
- Rate of breakdown of terrestrial contribution

6.6.3 QUALITY ASSURANCE

To assure confidence in detecting impacts caused by variable sources, paired plots that are ecologically similar will be located on and off tract. Sufficient samples of each parameter at each site will be taken, when possible, to ensure statistical significance. Sample sites will be compared to determine any differences that could indicate an impact. All parameters will be measured concurrently at a given site so that meaningful relationships can be established. For example, plant stress (chlorophyll A content) will be measured at the same time as levels of toxic chemicals in the soil to determine if there is any relationship.

To ensure accuracy and consistency in data collection, the methods approved for and used in the baseline study (Ref. 6-3) will be continued. In addition, data-checking programs for review of data in computer processing will be instituted. All data will be available for review by the Area Oil Shale Supervisor at any time.

Data collection and analysis will be conducted using standard methods recognized by experts in the field.

6.6.4 MONITORING MODEL CONSTRUCTION

A monitoring program should satisfy legal requirements, be effective and economical, incorporate flexibility, and provide contingency plans for occasions when normal limits are exceeded.

Ecosystem resolution can be carried from the most gross features (macro-structure/function) to the most miniscule (microstructure/function).

Baseline studies comprise one or more years of data collection revolving around important environmental parameters. The baseline serves the purpose of identifying and characterizing the principal biological components and their interactions among and within themselves, and to overriding driving variables such as climate, geology, and hydrology.

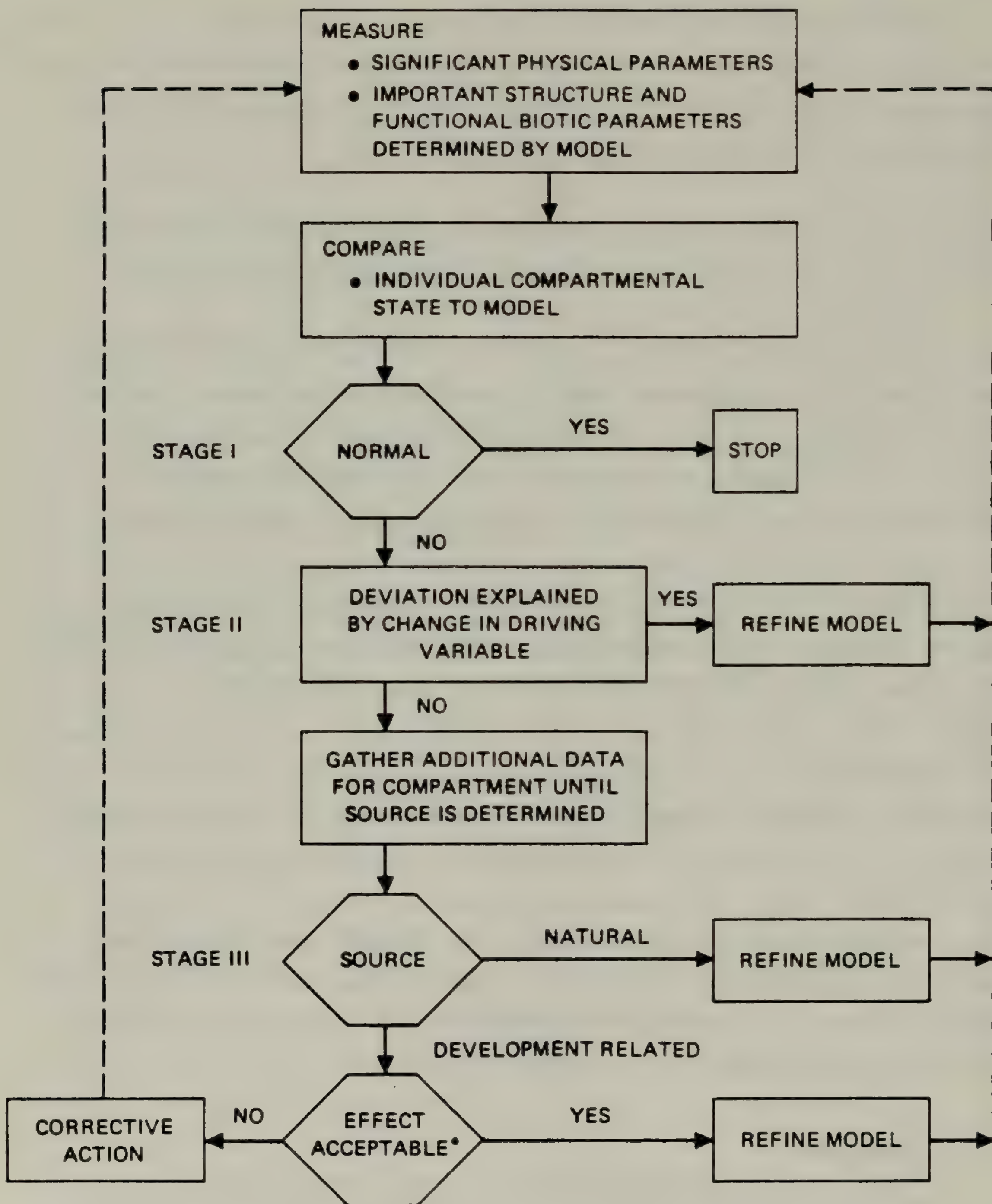
The monitoring program will be based on the contingency flow models shown in Figure 6.6-1 for nonreclaimed areas and Figure 6.6-2 for reclaimed areas. The different stages of analysis are described below.

6.6.4.1 Stage One

Ecosystem "health" is defined by the baseline and is supplemented during monitoring. Each of the four compartments is considered a "state variable" whose status determines compartmental "health." If a change in one compartment (or each compartment) can be explained by a change in any one or combination of the other three and is within the range of variability allowed by baseline analysis, then the system is healthy and the analysis is satisfied and proceeds no further.

6.6.4.2 Stage Two

If a compartment deviates from the allowable range or normal state as defined by baseline, and the deviation cannot be explained by change in other compartments, then Stage Two analysis begins. In this case, the structural and functional characteristics of within-compartment



*ACCEPTABLE IN TERMS OF LEGAL AND SCIENTIFIC PARAMETERS

Figure 6.6-1 FLOW MODELS FOR MONITORING NON-RECLAIMED AREAS

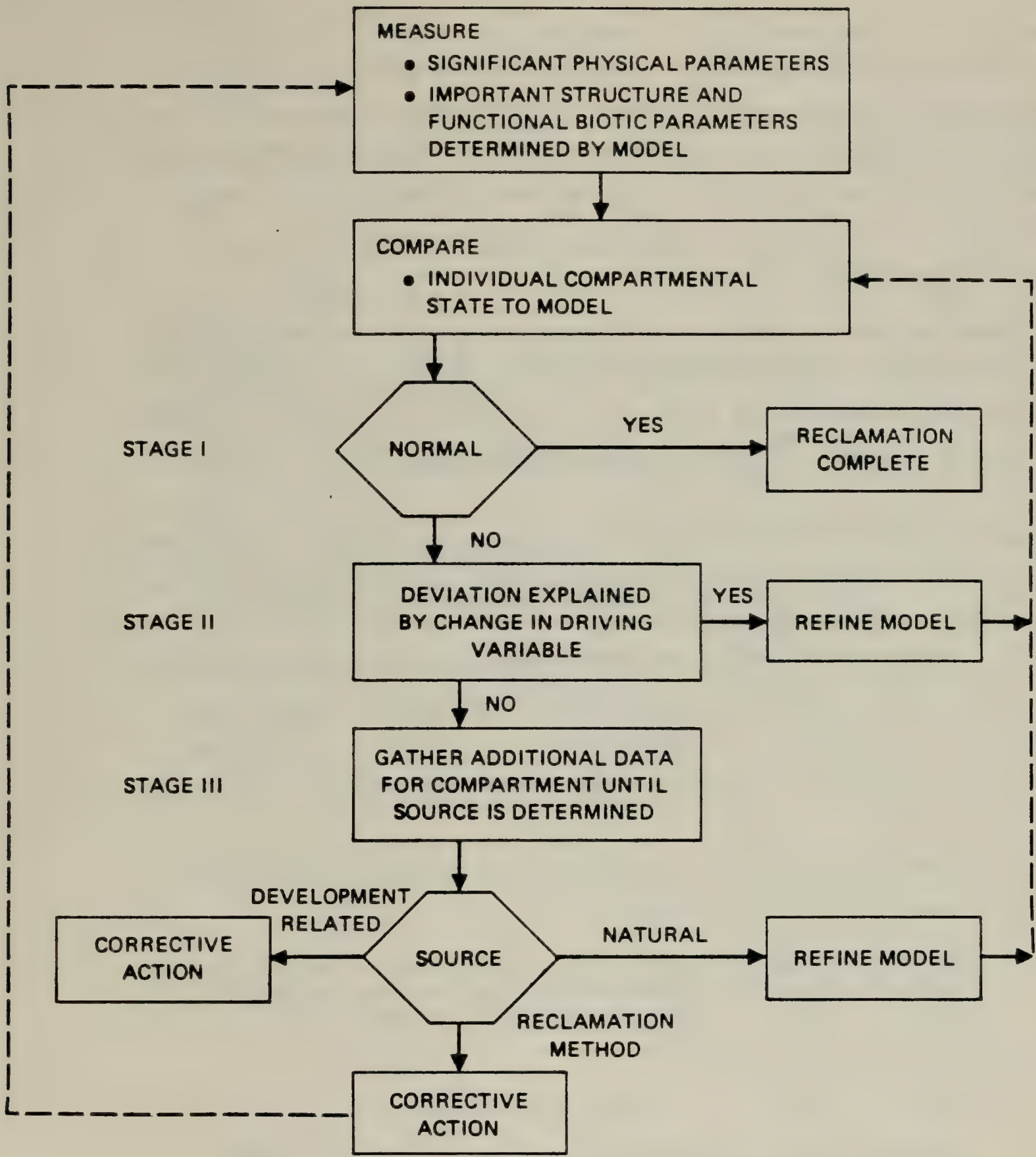


Figure 6.6-2 FLOW MODELS FOR MONITORING RECLAIMED AREAS

parameters is considered, i.e., subsystem structure, function, production. Analyzing each of these in relation to baseline isolates the "cases" for further analysis. These "cases" might be explained by subsets of other compartments' behavior and deemed "normal" or "healthy." If so, analysis stops. If not, the analysis enters the last stage.

6.6.4.3 Stage Three

This stage dictates a return to all data available from baseline with detailed analysis to elucidate the problem. If data are insufficient to do so, additional field studies are instituted to gather the needed information and take the appropriate corrective action.

For example, if a problem has been discovered that cannot be explained by detailed analysis through the contingency flow model through Stage Two, additional chemical analysis of the group under consideration might reveal a higher concentration of some trace element than existed during baseline. If this concentration exceeds the tolerance limit of the organism and is judged to be the cause of the deviation from normal, corrective action in pollution control methodology might be instituted.

Results of data collection and application of monitoring models are reported according to the following schedule:

- Immediately upon discovery, any unexplained deviation from normal state is reported so that further investigation and corrective action may be instituted at the earliest possible time.
- Progress reports are prepared semi-annually.
- A summary report is prepared annually including all data, data analysis, revised model, literature update, and recommendations.

For this type of contingency plan to be effective, the organisms to be monitored must be sampled initially to establish baseline conditions.

6.6.5 MONITORING MANUAL

At the beginning of the monitoring program, a detailed program manual will be prepared. This manual will be updated as necessary in connection with the monitoring report. The manual will include, but not be limited to:

- Introduction and monitoring rationale
- Annotated bibliography
- Detailed model relationships for all biotic and environmental parameters
- Detailed flow model of procedures to be followed in monitoring and contingency planning
- Detailed descriptions of all methods employed including appropriate statistical methods
- Data forms for all data collection
- Detailed contingency plan for each potential effect
- Appendices, table of contents, maps, etc.

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Section 7

ALTERNATIVES AND SELECTION RATIONALE

7.1 INTRODUCTION

Section 7 discusses the alternatives considered in the work done to date on the White River Shale Project. Since the Detailed Development Plan for the project is essentially a conceptual document, it must be understood that many of the alternative comparisons are not, at this time, based on the detailed data and analyses that would be the product of a full-fledged detailed engineering design. In many of these comparisons, there is a significant combined input of experience and judgment necessarily presented in qualitative or, at best, in semiquantitative terms.

The selection criteria are presented in Section 7.2 and the selection rationale is presented in Section 7.3. These are the guideposts and procedures that have been used as a basis for all the comparisons made. In the remaining sections, alternatives are discussed for all facets of the White River Shale Project.

7.3 SELECTION RATIONALE

The selection rationale is based on the project objectives presented in Section 7.2. The rationale associated with each of these objectives was developed as follows:

- Oil shale industry development
  - There was a search for available skills to determine the state of development for the selection of appropriate technologies.
  - The availability of appropriate technologies for use by White River Shale Project was determined.
- Environmental protection
  - Effects for each alternative were identified, analyzed, and quantified.
  - The effects of each alternative were compared with existing environmental control regulations.
- Economic return
  - Information was developed on resource recovery, energy recovery, and energy effectiveness for each alternative.
  - The total system was evaluated, since a given system may have one or more elements that are not individually the best choice.
  - Capital and operating costs were developed by standard procedures.

Final selection of the most probable case was the result of weighting the above information in an appropriate judgmental fashion.

7.4 LAYOUT OF FACILITIES

This section summarizes the alternatives considered for the layout of major facilities. This includes mine shafts, processed shale disposal area, material handling facilities, water management system, process and other facilities, soils handling, and access corridors.

7.4.1 OVERALL SITE REQUIREMENTS

As a result of current studies on the retorting process and material handling system, the overall site requirements may be able to be reduced. If the improved layouts for these facilities are adopted and the overall site is smaller, the impact of the site on the environment will also be less than reported in earlier layout studies.

7.4.2 MINE SHAFTS

The layout of underground operations has a range of alternatives, since the shale deposits underlie all of Tracts Ua and Ub and since all economically minable material is to be recovered during operation of the project. There are several technical advantages, such as balancing haulage distances, to operating from the centroid location of Tracts Ua and Ub. Flexibility in locating mine shafts at the surface is restricted only by topography and the processed shale disposal area. (Further details on mining alternatives are contained in Section 7.5.)

7.4.3 PROCESSED SHALE DISPOSAL AREA

Several disposal sites on Tracts Ua and Ub were considered for both Phase I and Phases II and III. Southam Canyon was selected, primarily because it is big enough to contain all of the processed shale produced during the life of the project on tract, and it does not present any serious environmental problems. (Alternatives for processed shale disposal equipment, water management, dust control, and revegetation are discussed in Section 7.10.)

7.4.4 MATERIAL HANDLING FACILITIES

One prominent feature of the White River Shale Project is a material handling rate that has rarely been equaled. Material handling methods take overall site layout problems into account and are responsive to the need for environmental protection. The combination of truck and conveyor system selected takes these factors into consideration. (Further discussion of material handling alternatives are contained in Section 7.5, 7.6, and 7.10.)

The overall site site requirements may be reduced as a result of individual studies to evaluate the retorting process.

7.4.5 WATER MANAGEMENT SYSTEM

In a broad sense, the water management system for the White River Shale Project relates not only to water made available to the project but to the control and use of the water in project operation. Thus, this section considers not only the alternatives of water supply and delivery but also the broad intent of the project's drainage plan and water utilization.

The water supply alternatives considered are 1) water from a reservoir behind a dam to be built by the state of Utah on the White River in a location close to Tracts Ua and Ub or 2) a supply of water from the Flaming Gorge Reservoir via Green River to be delivered by pipeline to Tracts Ua and Ub. (These and other alternativ s are discussed in Section 7.14.)

The intent of the project's drainage plan is to maximize the use of natural drainage courses, ensure the retention of contaminants, and prevent erosion as a result of project activities. Drainage and contaminant control as well as erosion control will be accomplished with ditches, surface grading, revegetation, stabilizing techniques, and dam impoundments. (These facilities and alternatives are discussed in Section 7.14.)

Since reuse of water is an essential ingredient in the proposed plan, alternatives for wastewater treatment methods and facilities are evaluated in Section 7.15.

7.4.6 PROCESS AND OTHER FACILITIES

The specific layout of process, support, and ancillary facilities was limited by the constraints of the underground operations and by the rough and rugged terrain of Tracts Ua and Ub. In the various alternatives presented in Section 7, the limited extent of available options has been taken into account. Perhaps the most important factor in facilities location was that of transportation related to the very large volume and weight of materials to be handled. The impact of these operations on the environment has been recognized and evaluated.

7.4.7 SOILS HANDLING

The rough and rugged terrain of Tracts Ua and Ub, together with the objective of minimizing shale handling distances, leaves little latitude in selecting the most appropriate site for earth moving during the construction phase. Within the limits of available alternative locations, every effort has been made to minimize earth disturbance. Site preparation methods and procedures have been adapted to the particular area. (Further details of soils handling alternatives are contained in Section 7.9.)

7.4.8 ACCESS CORRIDORS

Access to Tracts Ua and Ub for movement of men, material, and supplies, both to the project and away from it, has been discussed with a wide variety of state and government authorities who are interested in immediate and long-range plans for access corridors. These conversations have, of necessity, been preliminary, but they have nevertheless been very useful in formulating provisions for the most probable plan of action. Further consideration will be given to all of these very important corridor access problems as the project develops and as additional definitive data become available.

7.5 MINING

This section discusses common mining methods and evaluates their potential for extracting oil shale from Tracts Ua and Ub. Apart from the constraints imposed by the environmental and economic criteria against which all activities of the White River Shale Project must be measured, the mining operation is further constrained by the lease stipulation that all operations be confined within the boundaries of the leased tracts. Topography will be affected by mining and crushing facilities, shale stockpiles, removed soil, and the process shale disposal area. Various haulage systems are also evaluated. Three categories of mining were investigated: surface, underground, and in situ.

7.5.1 SURFACE MINING

The surface terrain of the area consists primarily of deep canyons and pinnacle-topped ridges, and the oil shale of acceptable quality for retort feed material lies 600 to 1,200 feet below the surface under rock and low-grade oil shale. The depth of the commercial mining zone makes any kind of surface mining environmentally unacceptable and technically and economically impractical. The Birds' Nest Aquifer would have to be dewatered before removing it by stripping. The surface would, of course, also be completely removed. The impossibility of disposing of the overburden and processed shale on site while achieving any reasonable amount of resource recovery makes surface mining of Tracts Ua and Ub unfeasible.

7.5.1.1 Strip Mining

A typical strip mining operation is illustrated in Figure 7.5-1. The hazard presented by slope instability of the spoil bank at this extreme depth eliminates strip mining as a possibility for the White River Shale Project.

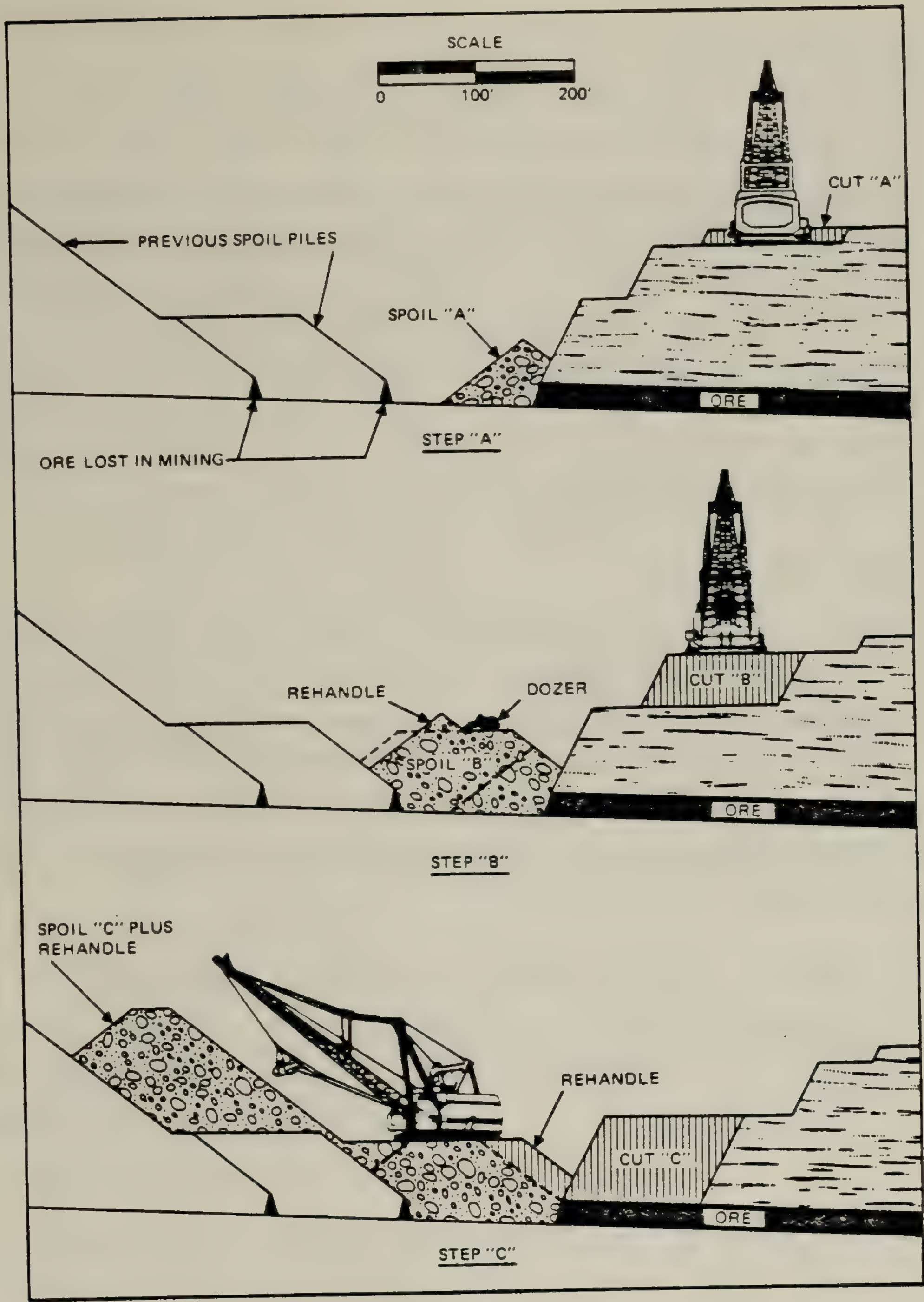

Figure 7.5-1 A TYPICAL STRIP MINING SYSTEM

7.5.1.2 Open-Pit Mining

Theoretically, open-pit mining of the present commercial zone could optimally recover 80 percent of the available ore (as compared with the anticipated 63 percent in the most probable plan); however, this figure could never be actually achieved because of the area required for disposal of overburden and processed shale. The stripping ratio would be close to 10 tons of overburden per ton of shale mined. In the late stages of the project some of the previously removed overburden and processed shale could be placed back in the pit along with that currently being produced, but rehandling large volumes of waste material is uneconomical. A typical open-pit mine is shown in Figure 7.5-2.

7.5.2 UNDERGROUND MINING

Mining underground causes little surface disturbance, is economically practical, and is the traditional approach for mining ores at depths at which oil shale is found in Tracts Ua and Ub. Subsidence is an important environmental effect to be considered. The Bird's Nest Aquifer overlies most of the mining area, and the probable effect of mining on this aquifer is discussed in Sections 4.5 and 5.3. The facilities that will be built aboveground are described in Section 3.5.

Since the mining zone does not outcrop within the lease boundaries, all underground mining methods must include facilities to either hoist or convey the mined shale to a surface retort site. The most probable plan proposes a production shaft in Phase I, followed by inclined shafts in Phases II and III.

Underground mining methods considered include room-and-pillar, longwall, and block caving. These methods are discussed below.

7.5.2.1 Room-and-Pillar Method

Room-and-pillar mining is appropriate in relatively flat-lying tabular ore bodies, such as those in Tracts Ua and Ub. Physical testing of drill

cores shows the strength of the oil shale to be such that subsidence, if any, will be minimal if extraction ratios and pillar dimensions are maintained within reasonable limits (Ref. 7-1).

Conventional drilling, blasting, loading, hauling or conveying, and crushing are employed in this method of mining. Continuous mining machines are not thought to be practical at this time because of the excessive fine material they create. All room-and-pillar mining methods considered for Tracts Ua and Ub have the following common advantages and disadvantages:

- Advantages
  - Resource recovery approaches 70 percent.
  - Minimal subsidence occurs when pillars are left intact.
  - High productivity is possible.
  - The method has been used in mining oil shale.
  - All excavated material is used, since all development is in the ore zone.
  - The method is historically safe.
  - Selective mining for grade is possible.
- Disadvantages
  - A complex ventilation system is required.
  - A large number of working places complicates logistics.

There are two types of room-and-pillar mining: single pass and bench. Each is briefly described and compared below.

Single Pass. In this method, the entire ore thickness is taken in one pass; a representative plan is shown in Figure 7.5-3. Single-pass room-and-pillar mining, as applied to Tracts Ua and Ub, has the following advantages and disadvantages when compared with room-and-pillar bench mining:

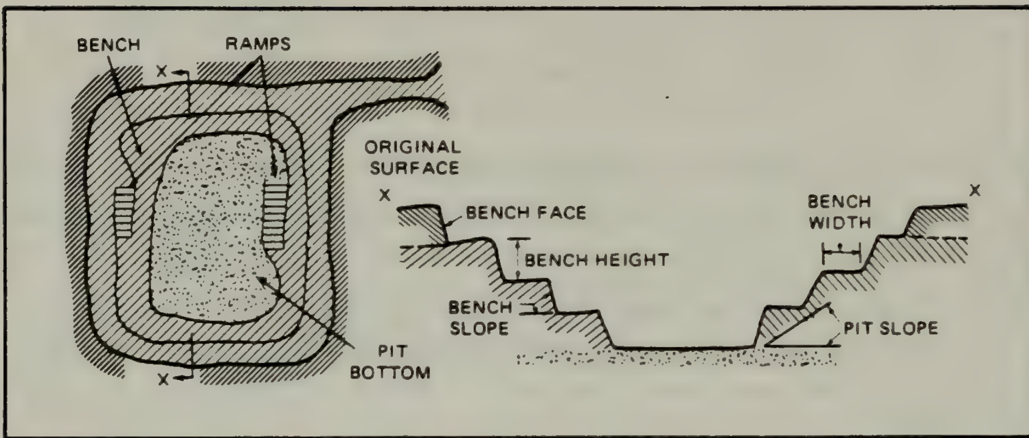

Figure 7.5-2 A TYPICAL OPEN-PIT MINE

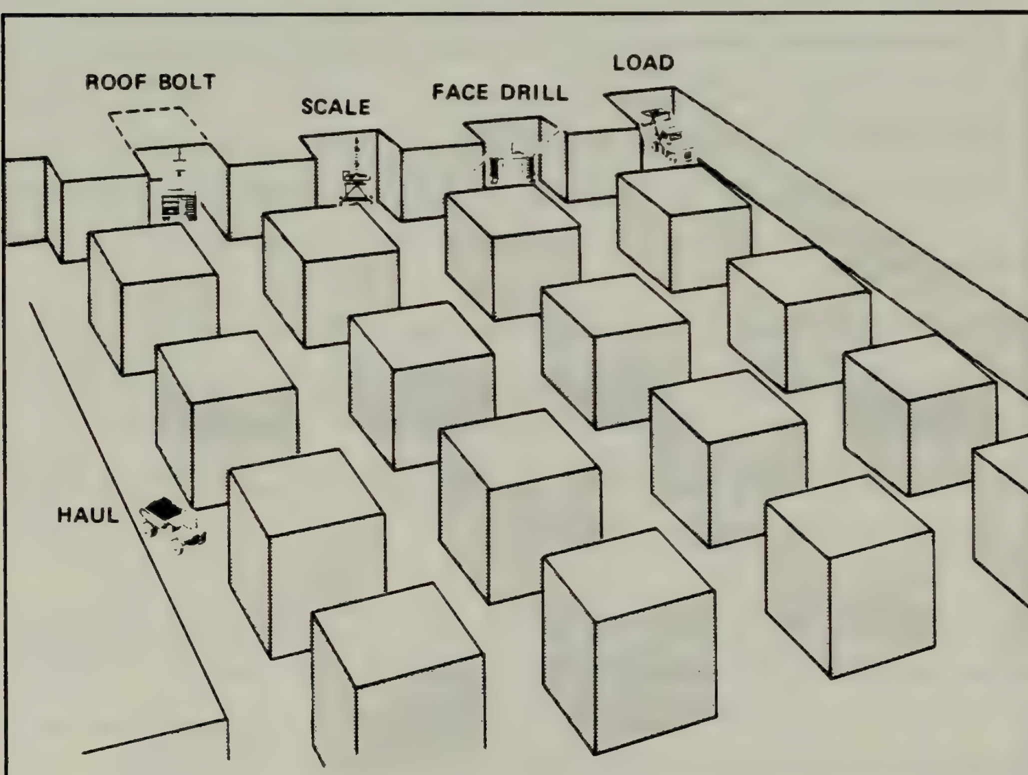

Figure 7.5-3 SINGLE-PASS ROOM-AND-PILLAR MINING

- Advantages

  - Blending for grade control is good.

  - Fewer blasting cycles create less pillar disturbance.

  - Drilling scaling, changing, loading, and hauling equipment can be standardized.

  - Fewer equipment moves are required for a given production.

- Disadvantages

  - Height of mining horizon requires very large equipment, which is not presently available.

  - Visibility is poor at great heights for drilling and scaling unless operators are raised to the roof height.

Benching. For thick deposits, a benching system of room-and-pillar mining is used to mine the ore from two or more levels or benches. Figure 3.5-8 shows a typical two-bench configuration. Bench mining has the following advantages and disadvantages when compared with single-pass mining:

- Advantages

  - Applicability has been proven in prototype oil shale operations.

  - Equipment technology has been developed.

  - Equipment can maneuver acceptably.

  - Visibility is better for drilling, scaling, and bolting.

- Disadvantages

  - Pillars are exposed to more blasting cycles.

  - Equipment must move more for given production.

  - Ventilation becomes more complex.

7.5.2.2 Longwall Method

Longwall mining in thin seams results in high resource recovery and permits a simplified ventilation system. A theoretical system for mining a thick seam is shown in Figure 7.5-4. Thick seams or veins have not been mined successfully by this method because it is difficult to control the roof before it caves, and caving and subsequent subsidence are inherent in longwall mining. Since subsidence is to be minimized and the zone to be mined is relatively thick, longwall mining is not the preferred mining method for Tracts Ua and Ub.

7.5.2.3 Block Caving Method

The vertical extent of oil shale presently suitable for surface retorting does not exceed 75 feet in the lease area. Block caving is usually used in much thicker or massive deposits; in the Ua-Ub deposit, development costs would be prohibitive. The block caving method is illustrated in Figure 7.5-5.

Oil shale tends to break into large slabs and blocks that complicate the recovery of ore from the draw points. The relatively thin zone to be mined and the need to minimize subsidence precludes the use of block caving in the proposed program.

7.5.2.4 Other Underground Mining Methods

While there are many other underground mining methods, none of them appears advantageous for the Utah lease tracts. Sublevel stoping is possible but the relatively thin mining zone precludes its use in the present plans.

7.5.3 IN-SITU PROCESSING

The present state of the art of in-situ processing is unproven and not sufficiently demonstrated to warrant its use at Tracts Ua and Ub. However, there is a possibility that in-situ technology could be used in the future to recover oil from the leaner shale and/or the remaining pillars that are not now considered commercially recoverable.

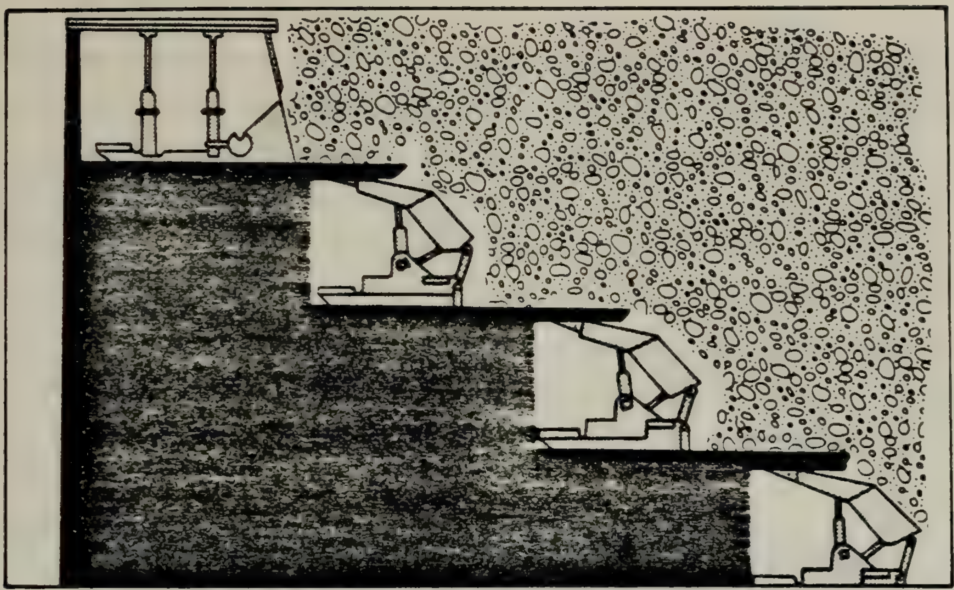

Figure 7.5-4 A TYPICAL LONGWALL SLICING SYSTEM

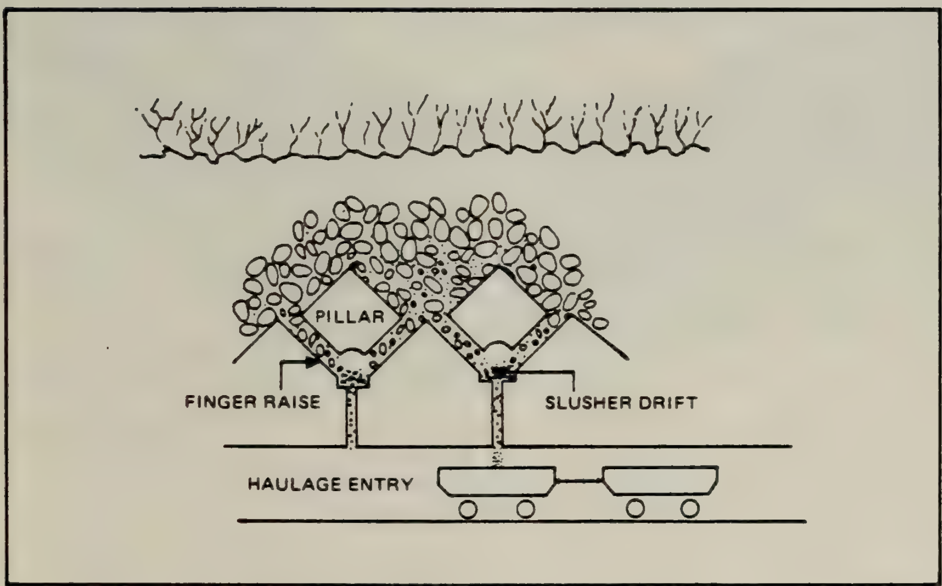

Figure 7.5-5 A TYPICAL BLOCK-CAVING SYSTEM

With the in-situ process, oil is released by retorting the oil shale in place. Some 15 to 30 percent of the shale is removed during development of the retort chambers. The underground retort chambers are then formed by blasting to produce a mass of shale rubble to fill development openings and the delineated chamber. This process is shown in Figure 7.5-6. The shale that is extracted may be retorted at the surface (with some concomitant problems of processed shale disposal), but the balance of the shale is burned underground by a process in which air and, possibly, an external fuel source are introduced. Liquid shale oil is then collected and pumped to the surface.

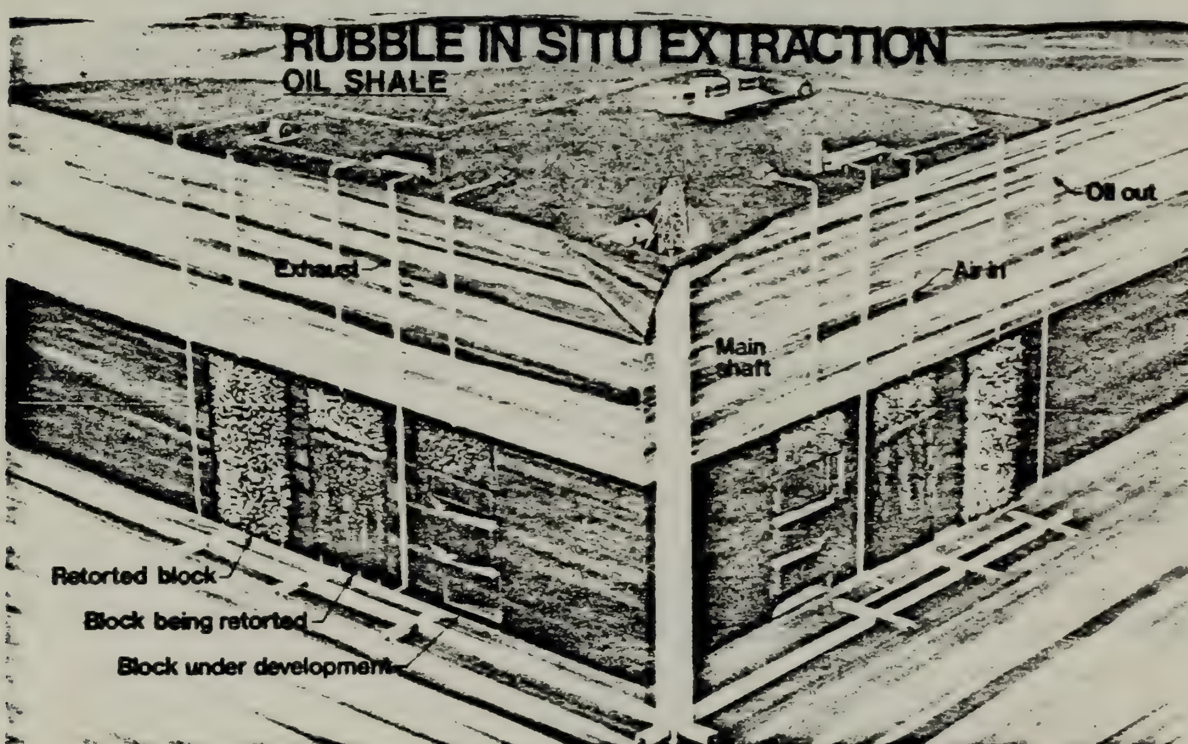

Figure 7.5-6 IN-SITU PROCESSING

7.5.4 HAULAGE SYSTEMS

Several haulage systems have been investigated for use in the project, each consisting of some configuration of truck, conveyor, or rail. As a rule, a conveyor system generates the least dust and trucks the most dust, but trucks are the most versatile form of haulage. At present, trucks, load-haul-dump units, and conveyor haulage are being considered.

Dust will be a problem and will have to be controlled in accordance with state and federal regulations. Several workable dust control systems do exist, and the most appropriate ones will be used for the final haulage system selected. Exhaust and emission control will also conform to all applicable regulations.

The haulage alternatives discussed all assume that primary crushing takes place underground.

- All Truck. If the distances are not excessive, truck haulage from the face to a centrally located primary crusher is an acceptable method. However, increased haul distances require additional trucks and drivers, which, in turn, increase ventilation and dust control requirements.

- Truck and Rail. If haul distances are greater than 2 miles and track grades are less than 3 percent, truck haulage from the face to a main line rail haulage system with centralized primary crushing is possible.

- Truck and Conveyor. Trucks haul the shale from the face to a primary crusher followed by a conveyor belt in a main entry. This method, which reduces the requirements for trucks, men, and ventilation air, was selected as the recommended procedure.

- All Conveyor. A load-haul-dump system takes the shale from the face to a portable crusher and cross belt, located in the panel, coupled with a main belt to a central hoisting location, which eliminates trucks from the haulage scheme. However, as the mine faces advances, the portable crusher and cross belt must be advanced. Portability of crushers and conveyors, as well as related dust control equipment, are matters to be considered when operating within the mining panels.

7.6 FEED PREPARATION ALTERNATIVES

This section describes the various processes and machinery considered for feed preparation for the retorts. This includes primary crushing, coarse raw shale storage and reclaiming, secondary crushing, material handling, and dust suppression.

7.6.1 PRIMARY CRUSHING

Primary crushing will take place underground and will reduce the mined shale to minus 12 inches, a size that can be transported easily to surface by either skip or conveyor. Locating this size reduction step underground has an environmental advantage, because it reduces land area requirements and aboveground dust production.

The equipment evaluated for primary crushing is discussed below.

7.6.1.1 Roll Crusher

Currently, a toothed single-roll-type crusher (see Figure 7.6-1) is recommended for primary crushing. It is superior to the other types of crushers because it:

- Slips less on shale-type material than jaw and gyratory crushers
- Produces the least amount of fines when breaking shale
- Has been used successfully on oil shale
- Can be disassembled for underground installation and maintenance
- Produces the greatest percentage of large material in the desired size range of minus 3 inch to plus ½ inch or minus 2 inch plus 1/8 inch as required

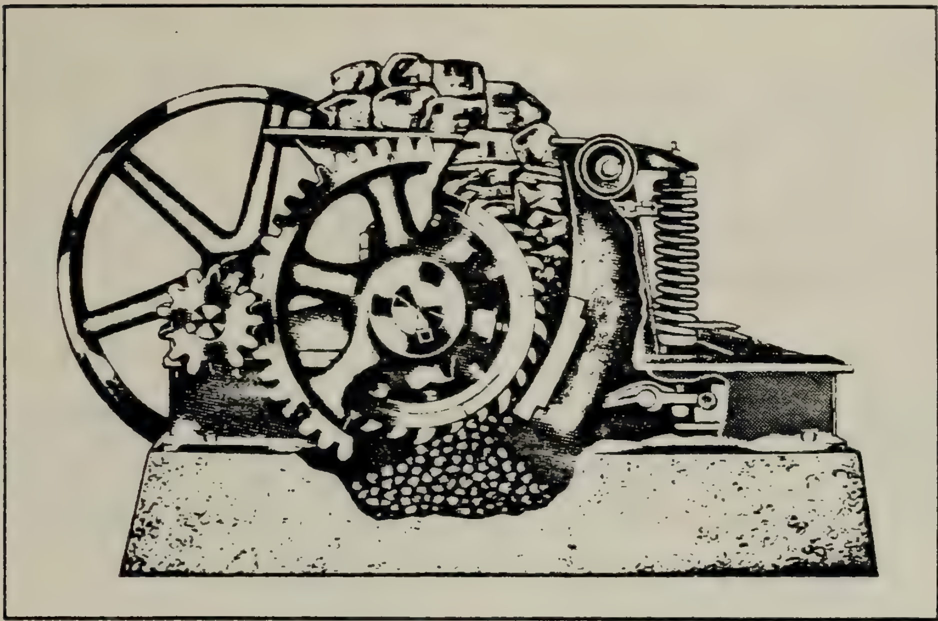

Figure 7.6-1 TYPICAL ROLL CRUSHER

- Requires somewhat less massive construction because of its steady, continuous movement than does a jaw, cone, or gyratory crusher
- Can handle pieces of shale as large as 3 feet by 4 feet by 5 feet

7.6.1.2 Jaw Crusher

Jaw crushers are relatively small and easily disassembled for installation and maintenance, and they produce a favorable ratio of larger pieces of shale to fines. Their chief disadvantage is that they tend to deform or mash the oil shale (which is somewhat spongy) instead of breaking it, resulting in clogging and less efficient operation. Jaw crushers also require higher power and regulated feed.

7.6.1.3 Impactor

An impactor or hammermill uses the differential velocity of feed material; the material strikes a high-speed horizontal rotor (hammers) and is slung by the rotor against a breaker-plate which crushes it. This method produces a high ratio of fines in soft materials such as oil shale and is therefore not considered suitable.

7.6.1.4 Gyratory Crusher

A gyratory crusher operates on the principle of one cone revolving eccentrically inside another to crush the material between them. Its advantages are high tonnage throughput and the ability to handle slabby material. These seem to be outweighed by the following disadvantages:

- It is very large and difficult to install underground and would require very large excavations.
- It would tend to mash the oil shale, because shale is compressible to some degree, and thus would be less efficient than other types of crushers.
- It tends to produce a larger percentage of unwanted fines.

7.6.1.5 Feeder Breakers

Feeder breakers use a flight chain conveyor to move material through a restricted sizing area containing a rotating breaker roll from which carbide tipped bits project. This method is suitable for use where high volumes of unsized material must be processed with minimum fines production.

7.6.2 COARSE RAW SHALE STORAGE AND RECLAIMING

Raw shale not immediately needed for processing will be stockpiled after primary crushing (possibly as much as 1,200,000 tons) to ensure continuous feed to secondary crushing if mining or primary crushing are interrupted. A tripper conveyor is planned to distribute the oil shale. A rail-mounted traveling stacker was examined but not considered viable. Transport conveyors from the mine will discharge the primary crushed oil shale onto

the stacker belt, and a traveling stacker or tripper belt will distribute shale on the stockpile. Oil shale will be reclaimed from the stockpile by apron feeders onto a belt conveyor through a reclaim tunnel.

The stockpile will be located on the surface near the secondary crushers, as shown in Figure 3.4-4. The dust control program is described in Section 4.1.

7.6.3 SECONDARY CRUSHING

Roll crushers are preferred for the surface secondary crushing because they do not produce a large quantity of fines or dust. They are also effective for size reduction of slabby material. Two alternatives were considered: impactors and cone crushers.

Impactors do not clog as easily as compression-type crushers. However, they may not be suitable for oil shale because they 1) generate an excessive amount of fines and 2) produce wear on hammers and abrasion-resistant parts that is so high as to make maintenance cost prohibitive.

Cone-type crushers operate on a principle similar to the one involved in gyratory crushers. The cone-type crusher would tend to clog on shale material, would produce too high a ratio of fines, and would not work best in the size range involved.

7.6.4 MATERIAL HANDLING

The material handling alternatives considered for transporting raw shale through the mining and crushing process areas are haulage by truck, by conveyor, and skip hoist. These are discussed below in terms of the process involved.

7.6.4.1 Mining and Primary Crushing

In Phase I, upper-bench shale is crushed in feeder breakers located close to the mining faces and is then transported by conveyor to a production

shaft surge bin. Lower-bench shale is trucked to a primary crusher located at the production shaft and is also stored in the surge bin until hoisted to the surface.

Phase II and III will use conveyor belts operating in inclined shafts, in addition to the Phase I hoisting system, to transport the shale from the underground crushers to the surface. A typical skip hoist installation is shown in Figure 7.6-2. Conveyor belt haulage systems from the mine to the surface for transporting the added Phase II and Phase III production requirements has a total cost and availability advantage over shaft hoisting.

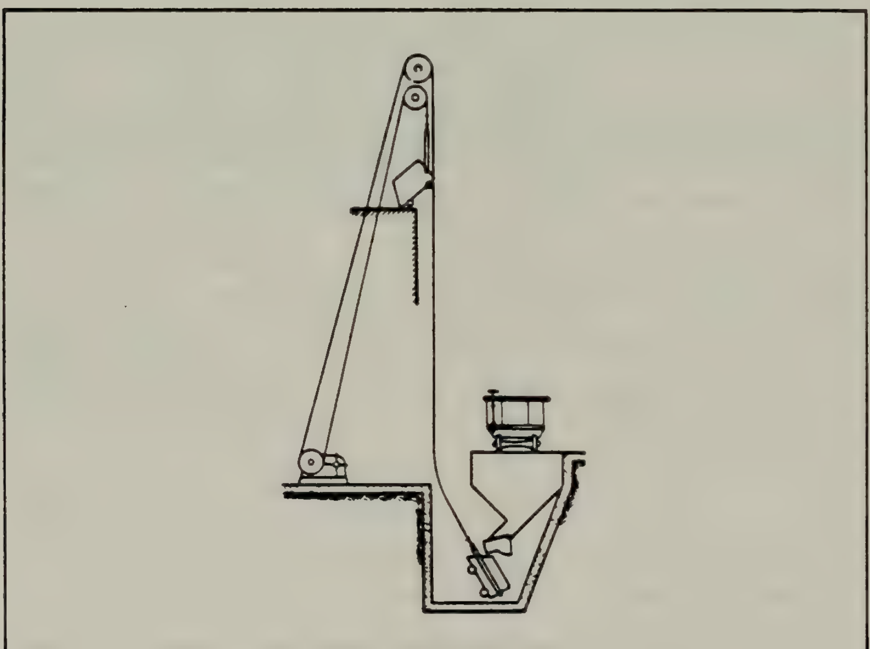

Figure 7.6-2 DOUBLE-BUCKET HOIST FOR LARGE-SCALE DEEP-LIFT OPERATION

7.6.4.2 Secondary Crushing

The layout of facilities and the properties of crushed raw shale make continuous conveyors the clearly preferred material handling alternative, since fugitive emissions of shale dust are more easily controlled, and roadway dust is eliminated.

7.6.4.3 Fines Handling

Two alternatives were considered for handling fines produced during the crushing and screening operations: stockpiling for eventual recovery and disposal with processed shale. Present plans call for fines-type retorts to be installed in Phases II and III to process any fines produced during those phases. During Phase I, fines will be stockpiled for recovery during the commercial phases, with the exception of fines produced during rescreening of stored shale, which will be disposed of with the processed shale.

7.6.5 DUST SUPPRESSION

The preferred dust suppression system is dust collectors used in conjunction with water spraying at critical, exposed points. Bag houses, the only other alternative considered, were considered less desirable because of their high maintenance cost and because they would probably become clogged by moisture or oil-bearing dust in this particular shale operation.

7.7 RETORTING

This section explains the fundamental ideas of retorting, describes the major alternative retorting processes, and compares environmental impacts of the alternative processes. For the White River Shale Project, the retorting system is a combination of vertical direct-heated and indirect-heated retorts for processing the bulk of the shale, with fines handled in indirect-heated "fines" retorts, as discussed in Section 3.7.

7.7.1 GENERAL DESCRIPTION

The term "retorting," as applied to oil shale, refers to the process of adding heat to the shale to decompose its organic material (kerogen) into gas and liquid hydrocarbons. There are two basic categories of retorting: in situ and aboveground. In the in-situ process, thermal decomposition is effected below ground (Section 7.5). In the aboveground process, retorting is performed in vessels (retorts) in which the heat is applied to crushed shale. Two types of heat input for retorting processes exist: in one, the retort is direct heated (DH); in the other, the retort is indirect heated (IH).

7.7.1.1 Direct Heated Retort

A direct heated retort is one in which oil is recovered from the shale by means of heat that is generated entirely within the retort. A simplified schematic diagram of a DH retorting system is shown in Figure 7.7-1.

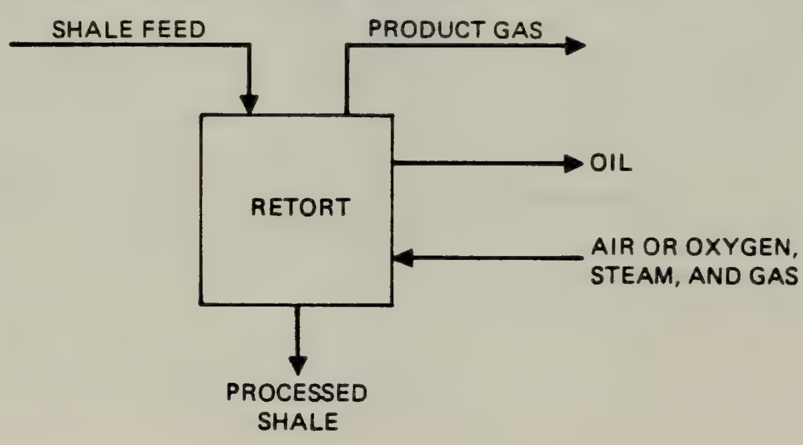

Figure 7.7-1 DIRECT HEATED (DH) RETORTING SYSTEM

Residual carbon on the retorted shale and some recycle gases are burned within the retort. This combustion heats the shale, causing oil and gas to be released, and the products flow out of the retort.

7.7.1.2 Indirect Heated Retort

An indirect heated retort is one in which gas and oil are recovered from the shale by means of heat that is generated outside the retort. A simplified schematic diagram of an IH retorting system is shown in Figure 7.7-2. A heat carrier (either a gas or a solid) circulates continuously through the retort to heat the shale, the heat being supplied to the carrier by the burning of fuel in a heater or an external combustor. As the shale is heated, oil and product gas are released and exit the retort.

Any conventional fuel can be used in the heater of an IH process. When this fuel is mixed with air in the heater and combusted, flue gas is produced. In all the processes to be discussed in this section, the flue gas either is clean or can be made so by further treatment.*

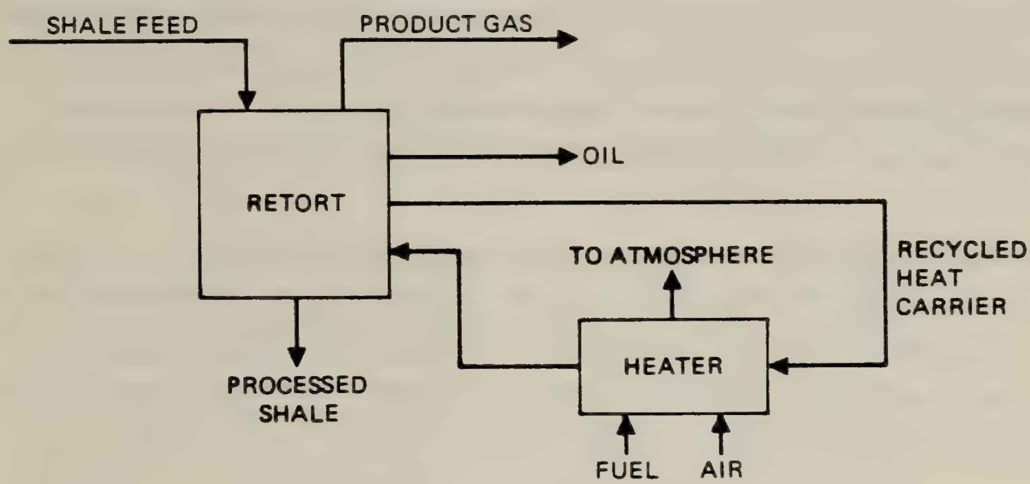

Figure 7.7-2 INDIRECT HEATED (IH) RETORTING SYSTEM

*As used in this discussion "clean" is defined as meeting appropriate regulations. This is discussed fully in Sections 4 and 5.

7.7.1.3 Product Gas and Oil

The product gas generated from the DH and IH retorting of the oil shale consists of combustible hydrocarbons, oxides of carbon, sulfur compounds (particularly hydrogen sulfide), and, in the case of a DH retort, nitrogen gas if air is used for combustion, which is the usual case. In both the DH and IH processes, the product gas leaving the retort is processed for removal of sulfur compounds. The product gas is a fuel gas that produces a clean flue gas when combusted.

Either DH or IH product gas can be used as a fuel within the facility. Because DH gas ordinarily contains a significant amount of nitrogen, the product gas from a DH process is a low-Btu (low heating value) gas. On the other hand, the product gas from an IH process is a high-Btu (high heating value) gas. A high-Btu gas has several advantages over a low-Btu gas: it is a superior fuel; it is more easily transported (less volume per Btu); and it is more adaptable to further processing, e.g., it is suitable as a hydrogen plant feedstock or as a marketable heating gas.

The product oil from the retorts is raw shale oil containing significant amounts of contaminants and must be upgraded to permit conventional refining and to minimize undesirable environmental effects. The degree of upgrading depends on the final use of the refined shale oil products.

The range of upgrading process alternatives is discussed more fully in Section 7.8, "Shale Oil Upgrading." The differences in environmental impact of the various retorting processes, relative to product gas and oil, become more apparent when the on-tract system of retorting plus upgrading is considered as a whole.

7.7.1.4 Raw Shale Feed Requirements

Before the raw shale can be processed in an aboveground retort, it must be crushed. The size of the crushed raw shale that can be processed varies from one type of retort to another. Some retorts require fine particles (approximately 1/2-inch maximum dimension) while others can handle only coarse shale

(less than 2 or 3 inches and greater than about 1/2 inch. Since the mining and crushing that precede the retorting are expected to produce about 10 percent of shale fines smaller than 1/2 inch, it is clear, from the standpoint of resource recovery, that the retorting systems capable of processing fines must be considered in selecting the best combinations of retorting processes for commercial operation.

Fines produced during Phase I operations will be stockpiled and will later be recovered and retorted during Phase III.

7.7.2 RETORTING PROCESSES

The major retorting processes considered in this plan are: Lurgi/Ruhrgas (LR), Superior, Paraho, Petrosix, Tosco II, and Union B. Since the Bureau of Mines process is essentially an early version of the Paraho process, it is not considered here. Also, the process offered by Dravo is very similar to the Superior process and the comments given for Superior also apply to this process. Simplified diagrams and brief descriptions of the six schemes above are given in Figure 7.7-3.

Table 7.7-1 summarizes the major features of the retorting systems that are being considered in this part of the report. Several items in the table deserve comment:

- The Lurgi and Tosco II schemes are capable of processing all the shale that is mined. In the Paraho and Petrosix schemes, the preferred raw shale feed particles are 1/2 inch and larger. The Union B requires 1/8- to 2-inch sized shale. It should be noted, however, that there is not necessarily any correlation between the ability to process fine shale particles and the yields of oil and gas. Other factors, related to the design features of the retorting systems, play an important role in determining these yields.

Table 7.7-1

COMPARISON OF THE MAJOR RETORTING PROCESSES

	Lurgi LR	Superior (Circular Grate)	Paraho		Petrosix	Tosco II	Union B
Type of Heating	IH	IH/DH	DH	IH	IH	IH	IH
Resource Recovery Factors							
Raw shale feed	Fines Only	Coarse Shale, No Fines	Coarse Shale, No Fines		Coarse Shale, No Fines	Fines Only	Coarse Shale, Some Fines
Some carbon in processed shale is used for heating	Yes	Yes	Yes	No	No	No	No
Estimated yield of C_5^+ shale oil per ton of shale	90	95	94	100	100	100	98
Estimated fuel oil yield, SCF/ton	1,500	6,900	7,300	1,100	1,100	670	710
Higher heating value, Btu/SCF	625	75	90	500	500	990	825

Environmental Considerations	
Processed shale	In the retorting of oil shale, the chief environmental problems are caused by the processed shale produced during retorting. These problems are similar for all retorting processes – leaching of salts at the disposal site, trace metals in the shale, shale permeability, compaction properties of the shale, and the stability of the shale pile – but they are more severe with finer particles. For a fuller discussion see Sections 4 and 5 of this DDP.
Product gas and raw shale oil	For a discussion of product gas and raw shale oil, see Section 7.8, "Shale Oil Upgrading."
Dust	Dust Control will be required in each of the retort facilities. Those processing finely graded shale are expected to have more severe dust problems.
Water consumption	The difference in water consumption between retorts is highly dependent on the entire facility built around the retort, and must be compared in that context.

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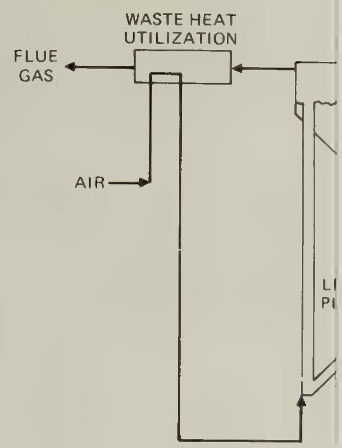
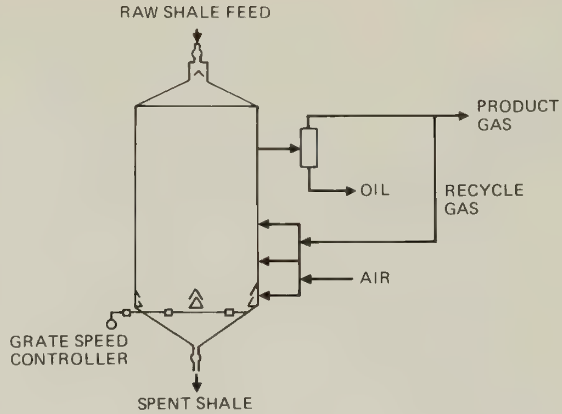


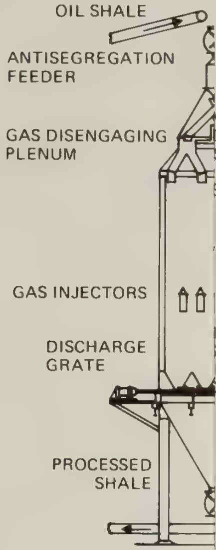
This method processes fine sh
processed shale is burned in th
shale from the lift pipe mixes
about an intimate mixing of th

PARAHO PROCESS



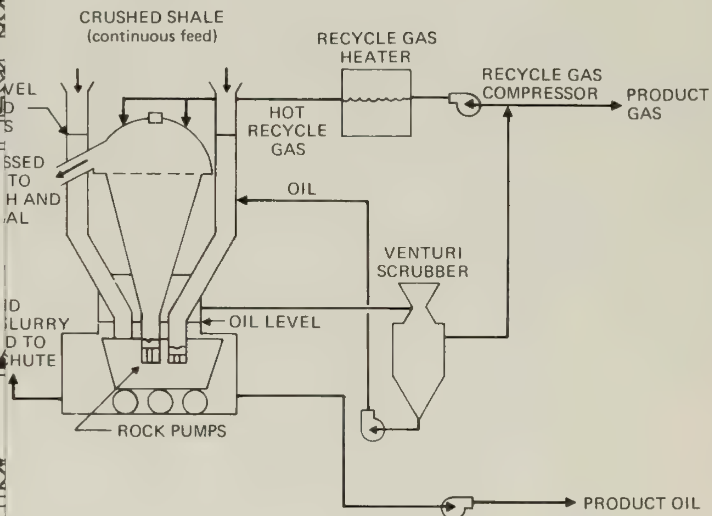
ho process shown operated in DH mode on coarse shale feed in a
haft retort in which the solids flow downward. The gas/air mixture
d into the shale bed at multiple levels and flows upward. The
oil leaves the top of the retort as an oil mist carried by the product
IH mode operation, the retort configuration is similar to the
retort.

PE



The Petrosix method processe
Within the retort, rock flows d
Heat for retorting is supplied b
and the hot gas is injected into

UNION B PROCESS



ion B retort processes coarse shale feed and some fines in a vertical
tort. Within the retort, rock flows upward (through the action of a
mp) and the heating gas flows downward. The type B retort is IH.

Figure 7.7-3 SIMPLIFIED DIAGRAMS AND BRIEF DESCRIPTIONS OF RETORTING PROCESSES

Table 7.7-1

COMPARISON OF THE MAJOR RETORTING PROCESSES

	Lurgi LR	Superior (Circular Grate)	Paraho		Petrosix	Tosco II	Union B
Type of Heating	IH	IH/DH	DH	IH	IH	IH	IH
Resource Recovery Factors							
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Some carbon in processed shale is used for heating	Yes	Yes	Yes	No	No	No	No
Estimated yield of C_5^+ shale oil per ton of shale	90	95	94	100	100	100	98
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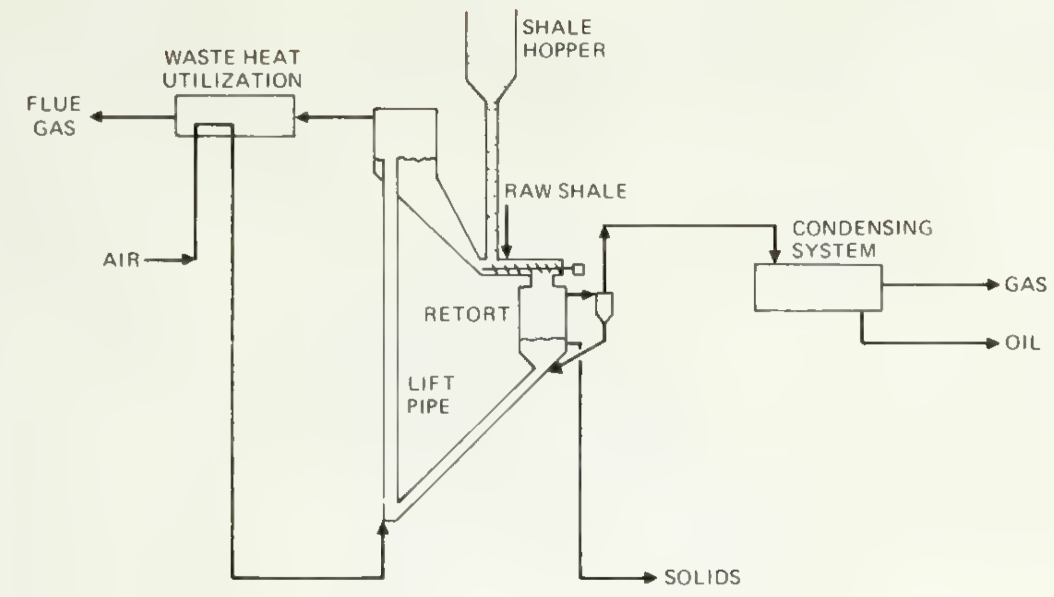
Higher heating value, Btu/SCF	625	75	90	500	500	990	825

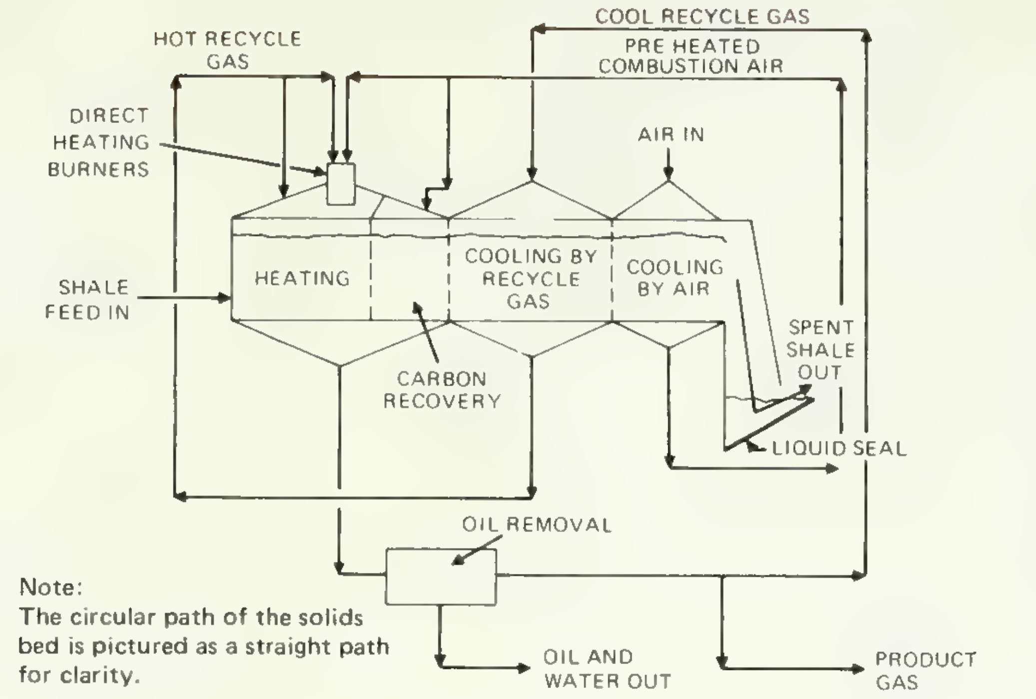
Environmental Considerations	
Processed shale	In the retorting of oil shale, the chief environmental problems are caused by the processed shale produced during retorting. These problems are similar for all retorting processes – leaching of salts at the disposal site, trace metals in the shale, shale permeability, compaction properties of the shale, and the stability of the shale pile – but they are more severe with finer particles. For a fuller discussion see Sections 4 and 5 of this DDP.
Product gas and raw shale oil	For a discussion of product gas and raw shale oil, see Section 7.8, "Shale Oil Upgrading."
Dust	Dust Control will be required in each of the retort facilities. Those processing finely graded shale are expected to have more severe dust problems.
Water consumption	The difference in water consumption between retorts is highly dependent on the entire facility built around the retort, and must be compared in that context.

LURGI LR PROCESS



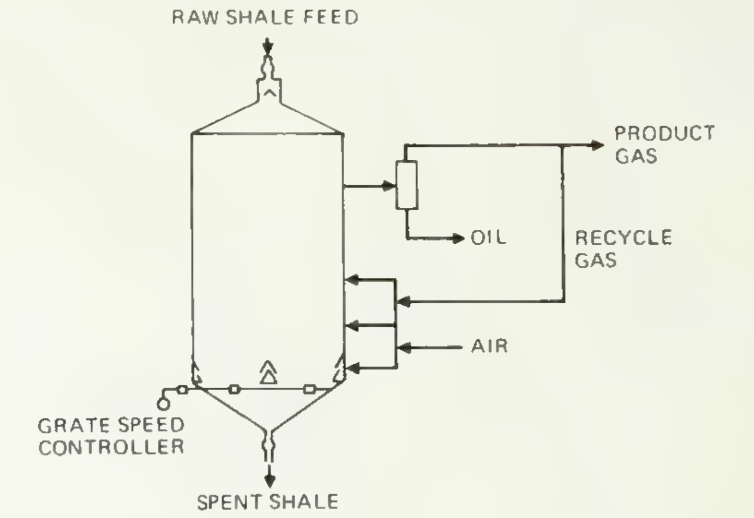
This method processes fine shale feed in the IH mode. Carbon in the processed shale is burned in the lift pipe, and the hot circulating processed shale from the lift pipe mixes with raw shale in a screw conveyor to bring about an intimate mixing of the solids.

SUPERIOR OIL PROCESS



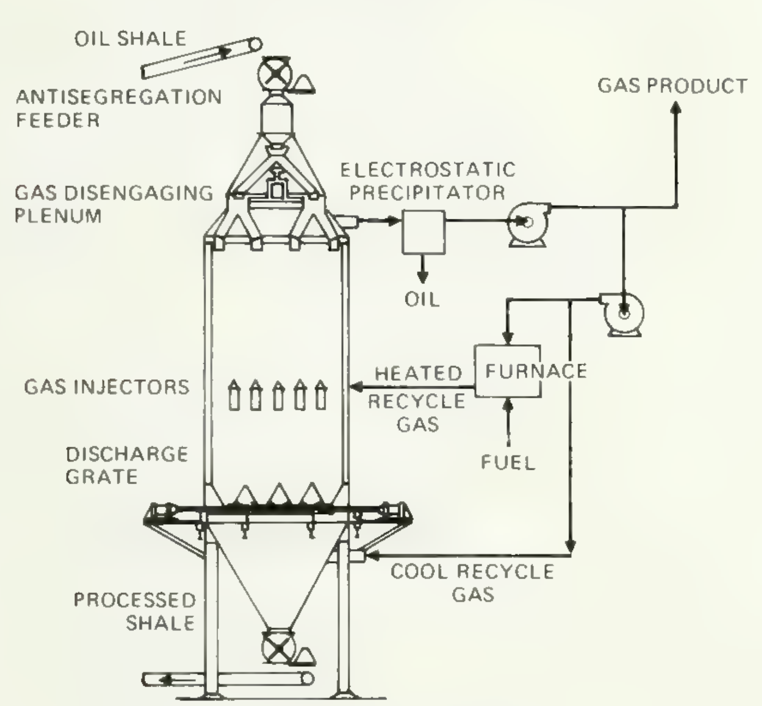
This process is operated as a DH retort and can accept coarse shale feed. This retort is a circular grate; shale is carried on a traveling grate in a circular path, and is successively heated and cooled by a gas passing through the grate. In the retorting zone, a gas/air mixture is combusted for heating the shale.

PARAHO PROCESS



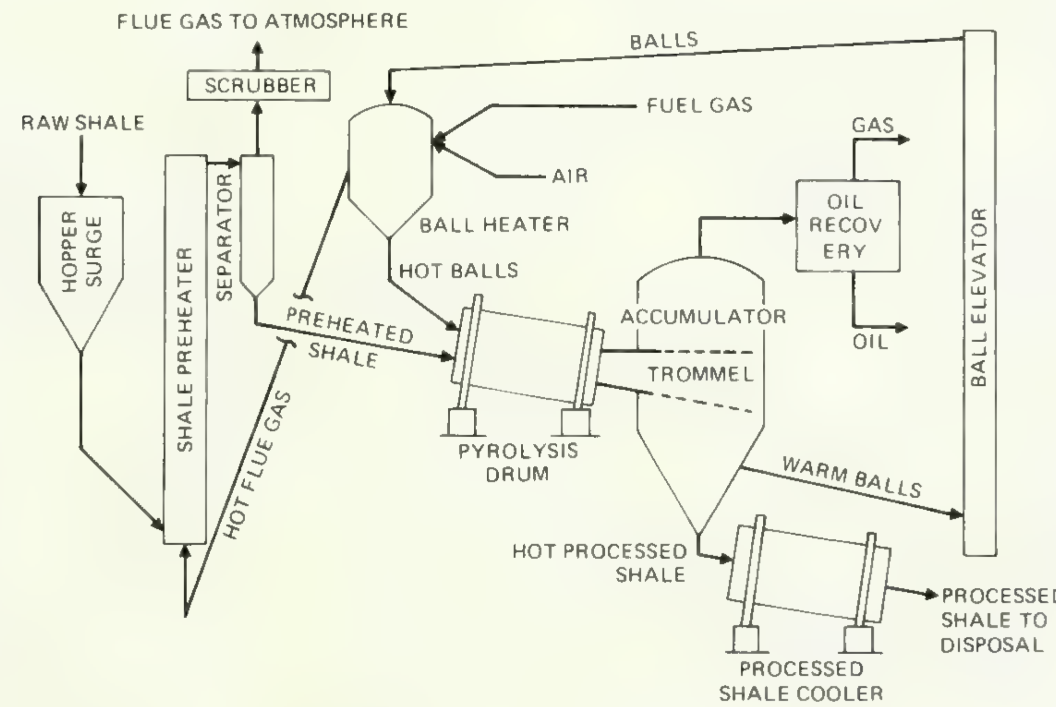
The Paraho process shown operated in DH mode on coarse shale feed in a vertical shaft retort in which the solids flow downward. The gas/air mixture is injected into the shale bed at multiple levels and flows upward. The product oil leaves the top of the retort as an oil mist carried by the product gas. For IH mode operation, the retort configuration is similar to the Petrosix retort.

PETROSIX PROCESS



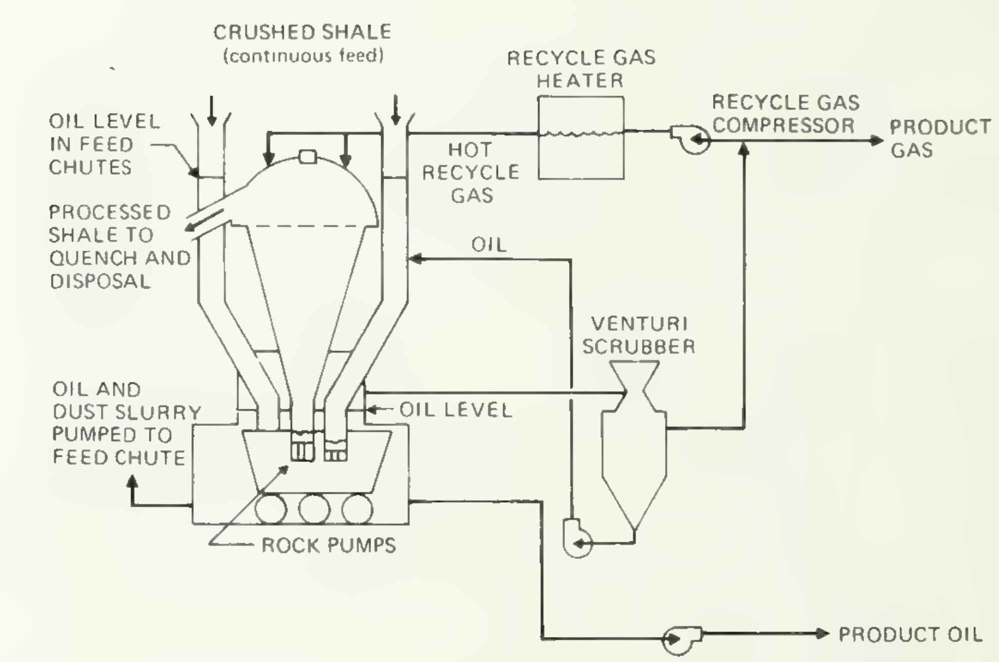
The Petrosix method processes coarse shale feed in a vertical-shaft retort. Within the retort, rock flows downward and the heating gas flows upward. Heat for retorting is supplied by a gas heated in a furnace outside the retort, and the hot gas is injected into the retort at one bed level.

TOSCO II PROCESS



The TOSCO II method processes fine shale feed in an IH retort. The shale is heated to retorting temperature in the pyrolysis drum by hot ceramic balls. The mixture of shale and ceramic balls is then separated in a trommel.

UNION B PROCESS



The Union B retort processes coarse shale feed and some fines in a vertical shaft retort. Within the retort, rock flows upward (through the action of a rock pump) and the heating gas flows downward. The type B retort is IH.

Figure 7.7-3 SIMPLIFIED DIAGRAMS AND BRIEF DESCRIPTIONS OF RETORTING PROCESSES

- The DH retorts and the Lurgi retort all use residual carbon in the shale as fuel. The residual carbon is burned inside the DH retorts with recycle gas serving as a heat carrier. In the Lurgi case, the residual carbon is burned externally and the processed shale is used as the heat carrier.

- The Union B, Tosco II, Paraho IH, and Petrosix retorts all produce retorting heat by combustion of conventional fuels in a fired heater external to the retort. The Tosco II process uses ceramic balls as the heat carrier. The other three processes use recycle gas as the heat carrier medium.

- Disposal of processed shale is the major environmental problem in the retorting of oil from shale. The processed shale can have different characteristics, with different degrees of environmental problems resulting. Processing of fines generally presents greater problems.

- For the various retorting alternatives, the product gas and oil produce different environmental impacts. These impacts are discussed in Section 7.8.

A combination of vertical DH and IH retorts for processing the bulk of the shale and fines-type retorts for processing fines (minus 1/2 inch) has been selected for the White River Shale Project. This combination is equivalent to any other process (or processes) in terms of resource recovery.

Since the art of retorting and retort design is evolving rapidly, the WRSP choice of a vertical retort may change. Similarly, the choice of the precise mode for processing fines will be between Tosco II or Lurgi or some other suitable retort.

7.7.3 PROCESSED SHALE COOLING

There are four basic approaches to cooling processed shale from the retort outlet conditions to the temperature level that will permit safe and reliable transport and disposal:

- Spraying with water on conveyors

- Air cooling on moving grates

- Rotary-drum water cooling
- Water immersion quenching

7.7.3.1 Spraying on Conveyors

In this system, water is sprayed onto material as it travels on belts and as it is transferred from one belt to another to obtain adequate cooling and mixing. The entire system is enclosed, and the dust-laden steam is treated by a high-efficiency wet scrubber system, with heat rejection to the atmosphere as described in Section 3.7.3. This system requires less equipment, with consequent lower cost, and increased reliability. On the other hand, the system encloses and transmits dust-laden air over a much wider area, and could make it difficult to wet (and, hence, cool) the processed shale adequately and to suppress dust.

7.7.3.2 Air Cooling on Moving Grates

This method uses equipment similar to cement plant clinker coolers. Material leaving the retorts is spread out on a moving metal grate through which air is blown upward to cool the material. Dust-laden air produced in this step is contained in a totally enclosed system and moved, as before, to high-efficiency wet scrubbers and ancillary equipment. The cooled shale is moisturized at the end of the cooling activity for dust suppression.

The advantage of this system is that it minimizes water requirements. Its disadvantages are the size of the equipment (which could take up much more room than a rotating-drum system or immersion quenching system) and the higher costs and reduced reliability associated with more mechanized equipment.

7.7.3.3 Rotary-Drum Cooler

In this method, processed shale leaving the retorts is conveyed to rotary-moisturizing-drum coolers, where its temperature is reduced by tumbling and by water sprays. Dust-laden steam and moist air produced in this step pass in an enclosed system from each drum to its own high-efficiency wet scrubber.

Additional water is added en route if necessary by venturi hydraulics. The scrubbers condense steam and remove dust.

There are four main advantages to a rotary-drum cooling system:

- The possible variables in this system ensure that any reasonable temperature could be achieved for processed shale en route to disposal
- An intimate mixing of water and solids can be guaranteed.
- The shorter distances required to ensure cooling simplifies layout with respect to other equipment
- The necessity for enclosing all conveyor systems is eliminated

A disadvantage of the system is that more fines from the coarse shale retort are produced, and the advantages are achieved at the price of higher equipment, maintenance, and operating costs.

7.7.3.4 Water Immersion Quenching

In this method, processed shale drops from the bottom of the retort into quench pits where the shale is totally immersed in water. The shale is removed from the pit by drag chain conveyors and placed on the processed shale conveyor where it is conveyed to the disposal site. Steam (with entrained dust) produced by cooling of the shale is sent to a water scrubbing system where the steam is condensed and cooled and returned to the quench pot.

This system has the advantages of minimizing fines but has the disadvantage of higher water requirements.

7.7.3.5 Selection Rationale

On the basis of information available at this time, White River Shale Project has selected the water immersion quenching for the coarse shale retorts and a rotary-drum cooling system for the fines retort as the most probable alternative.

7.7.3.6 Future Investigation

Extensive studies of shale cooling and moisturizing will be conducted during Phase I retort design and operation phase. Operating experience may change the preference stated above. Cooling on belts, air cooling on grates, or a combination of these methods may emerge as the most advantageous way to cool the processed shale.

A temperature in the range of 100F to 150F for the processed shale delivered to the disposal site is considered acceptable. Further technical studies are now being conducted to define an acceptable temperature for processed shale when it reaches the disposal site. Should a lower temperature be required than is now anticipated, it can be achieved by augmented spraying and lower water-quench temperatures. Flexibility to meet the eventual cooling requirements is a primary criterion for selection of a cooling method.

7.8 UPGRADING

This section relates the spectrum of upgrading technology available in demonstrated form to a range of final product oil qualities; defines the characteristics of these technological alternatives, as applicable to White River Shale Project; and explains the selection rationale.

7.8.1 RANGE OF UPGRADING ALTERNATIVES

Oil shale retorting yields raw shale oil that is viscous and waxy and contains impurities such as nitrogen, sulfur, and arsenic. The raw shale oil will be upgraded to some degree depending on its final use. In addition, there is retort gas to be processed, which serves as fuel for the project and, in some of the alternatives, as raw material for manufacture of hydrogen or for possible export from the plant site. The upgrading alternatives can be grouped according to the severity or intensity of processing, with the more severe operations resulting in the greatest change of shale oil characteristics. All of these processing schemes are available in demonstrated form from a number of licensors.

Four product oil quality objectives, and the upgrading required for each, are described:

Upgrading Required	Product Quality
None	Raw shale oil not readily transported by pipeline
Mild	A cracked shale oil more suitable for transport by pipeline
Moderate	Suitable as boiler fuel or refinery feedstock
Severe	High-quality refinery feedstock

These options are shown in Figure 7.8-1 in order of increasing severity of processing. Note that the options result in eight different upgrading schemes.

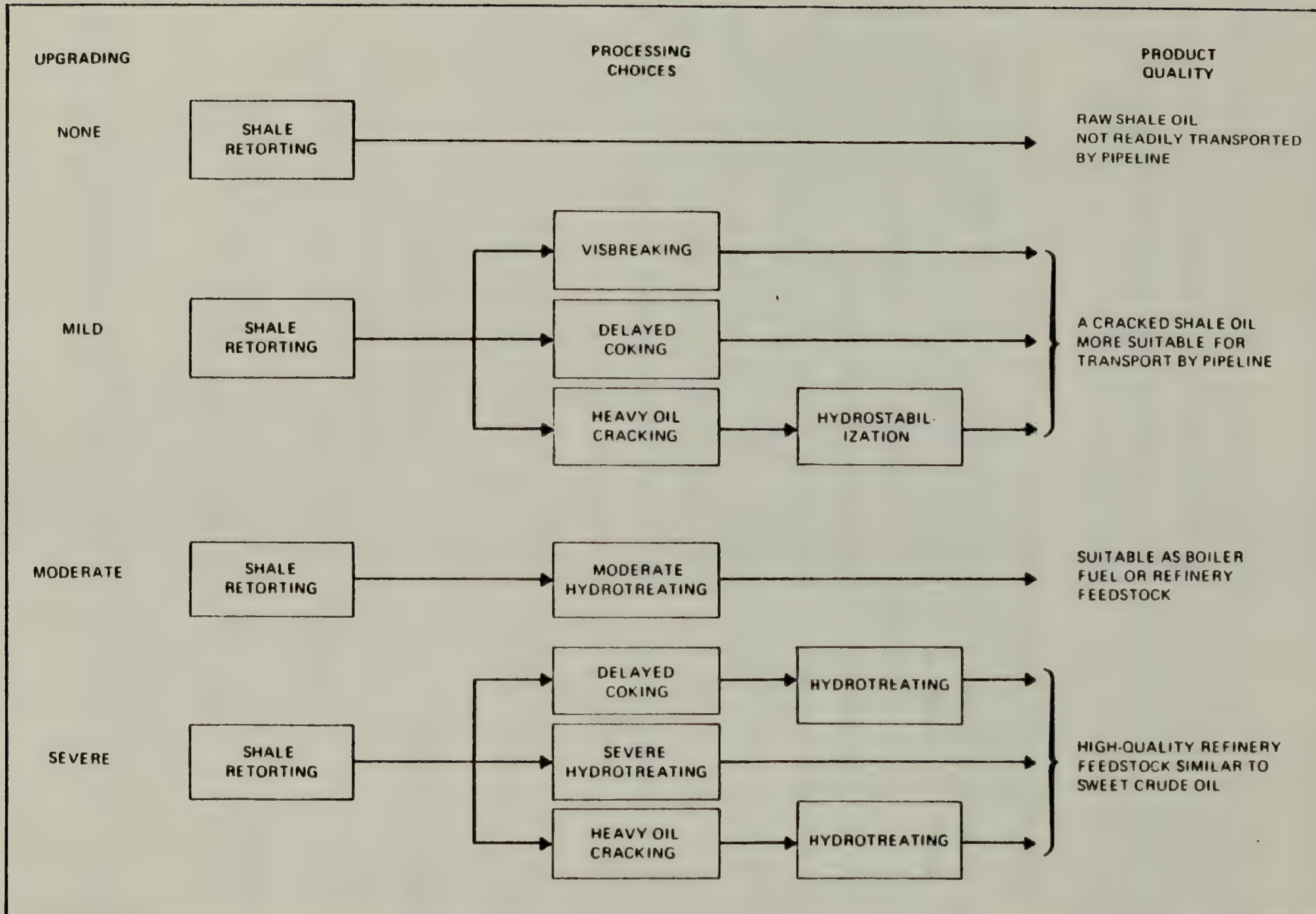


Figure 7.8-1 UPGRADING ALTERNATIVES

7.8.2 NO UPGRADING

In this option, no upgrading is performed at the site; the raw shale oil is shipped without modification to some offsite refinery for processing or to other available markets.

This option has at least one major drawback. Since the raw shale oil has a high pour point* (about 85F) and a high viscosity**, it is not readily transported by pipeline except by maintaining the temperature above the pour point, or by adding pour point depressant. Even when this is done, the oil will still be very viscous and will require relatively high pump power.

7.8.3 MILD UPGRADING

The second option is to produce cracked shale oil (Figure 7.8-2) that can more readily be pipelined to a refinery for further processing to ultimate products.

Shale oil can be cracked by visbreaking, by delayed coking, or by heavy oil cracking and hydrostabilization. In all three processes, the large hydrocarbon molecules of the raw shale oil are cracked (broken down into smaller molecules with lower boiling points). In visbreaking and delayed coking, the cracking is accomplished entirely by heat; in heavy oil cracking, it is accomplished by means of heat and a catalyst. Each process sharply lowers the pour point of the raw shale oil (e.g., from 85 to 35F); but since none of the processes significantly decreases the sulfur or nitrogen content of the raw shale oil, the cracked shale oil produced must be sent to a refinery for further processing if other markets are not available.

*The lowest temperature at which a specific liquid will flow.
**The measure of internal friction or resistance to flow of a liquid.

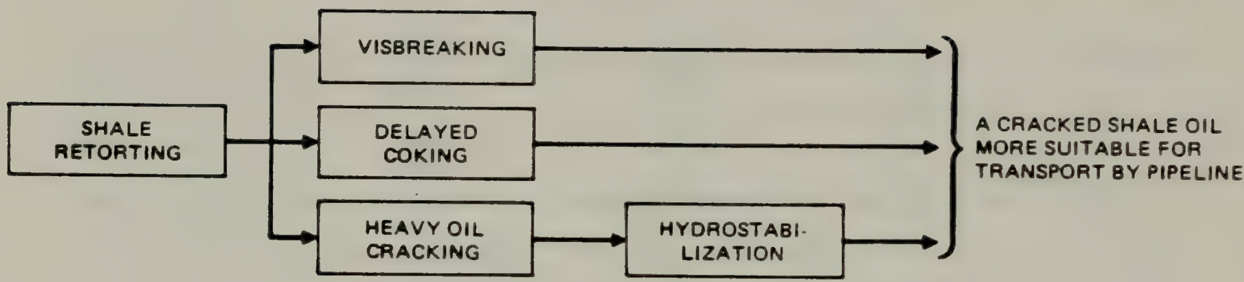


Figure 7.8-2 PROCESSING THE RAW SHALE OIL TO PRODUCE CRACKED SHALE OIL

7.8.3.1 Visbreaking

Visbreaking is a mild thermal cracking process that lowers the molecular weights of the hydrocarbon molecules only slightly. Although the process reduces the pour point of the raw shale oil, in this instance it has little effect on the viscosity, the term "visbreaking" notwithstanding.

7.8.3.2 Delayed Coking

Delayed coking is a semicontinuous thermal cracking process that produces a lower molecular weight distillate and a solid residue called coke. The distillate is the cracked shale oil. It has a low pour point and low viscosity.

7.8.3.3 Heavy Oil Cracking Plus Hydrostabilization

As is the case with the delayed coking, heavy oil cracking produces both lower molecular weight distillate and a coke residue, which deposits on the catalyst. However, in the heavy oil cracking process, the coke is burned off the catalyst and the combustion heat is recovered by producing steam. The distillate is chemically stabilized by bringing it into contact with hydrogen. The resultant cracked shale oil is similar in its properties to the cracked shale oil produced by the delayed coking process described above.

7.8.4 MODERATE UPGRADING

The third option (Figure 7.8-3) is to moderately hydrotreat the raw shale oil.. In the process of hydrotreating, the raw shale oil is brought into contact with hydrogen in the presence of a catalyst to remove the bulk of the sulfur, nitrogen, and oxygen from the oil. The process resembles the hydrostabilization process described above, except that here the consumption of hydrogen is greater. The resulting product has about the same pour point as raw shale oil, but has a lower viscosity, and is low in both sulfur and nitrogen. It can be more readily burned in a boiler and meets federal nitrogen and sulfur specifications (no stack gas treatment is necessary), or it can be sent to a refinery for further processing.

Figure 7.8-3 PROCESSING THE RAW SHALE OIL TO PRODUCE BOILER FUEL OIL

7.8.5 SEVERE UPGRADING

The most complete type of upgrading — converting the raw shale oil to a high-quality refinery feedstock similar to a low-sulfur crude oil — is shown in Figure 7.8-4. Three methods of obtaining this product are shown.

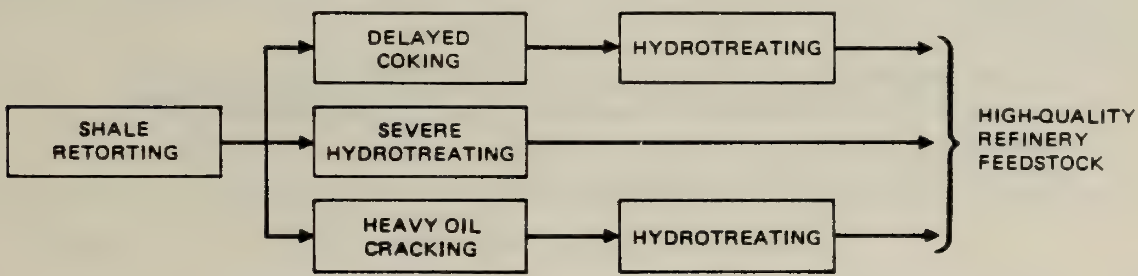


Figure 7.8-4 PROCESSING THE RAW SHALE OIL TO PRODUCE REFINED SHALE OIL

Each method produces an oil that has a low viscosity, and that is low in both sulfur and nitrogen. Severe hydrotreating does not significantly reduce the pour point, while the other two methods do. The upgraded shale oil produced is suitable for pipelining to, and further processing in, domestic petroleum refineries for conversion to a full range of products.

7.8.5.1 Delayed Coking Plus Hydrotreating

The first option, a combination of delayed coking and hydrotreating, uses the processes described in Sections 7.8.3 and 7.8.4.

7.8.5.2 Severe Hydrotreating

The hydrotreating process that directly converts the raw shale oil to upgraded shale oil is a much more severe* form of hydrotreating than the one used to make a boiler-fuel-quality oil.

7.8.5.3 Heavy Oil Cracking Plus Hydrotreating

This alternative combines the processes described in Sections 7.8.3 and 7.8.4.

7.8.6 UPGRADING SUMMARY

The following discussion presents a qualitative summary of the results of upgrading for the options described. For this discussion it is assumed that the retorting section of the plant is the same in all cases producing the same quantity of raw shale oil. The following general conclusions can be reached:

- As the severity of the upgrading is increased, the amount of product oil generally is reduced, but it becomes more valuable. Up to a 20 percent reduction in product weight results from various upgrading options.

*Higher pressure, reduced space velocity, temperature, catalyst consumption, and hydrogen use.

- The thermal energy efficiency of the facility becomes lower as the severity increases. The efficiency with no upgrading is approximately 75 percent and is reduced to around 70 percent after upgrading is added.

7.8.6.1 Power Export Potential

Each of the eight alternative processing schemes can be developed in any one of three ways with regard to potential for the facility to export power:

- Option A. All surplus fuel and steam are converted to electric power in a utility plant. Power in excess of that required for the oil shale facility is exported.

- Option B. The utility plant is sized only large enough to satisfy the power requirements for the oil shale facility. The utility plant includes sufficient spare equipment to preclude reliance on an outside power source. Fuel in excess of that needed in the utility plant is exported.

- Option C. There is no utility plant, except for a startup steam boiler. The power required for the oil shale facility is purchased. All surplus fuel and steam are exported.

7.8.6.2 Environmental Effects

The following broad questions should be considered when evaluating environmental effects of upgrading alternatives:

- What is the environmental effect of energy export or flaring of significant quantities of non-shale-oil energy?

- What is the environmental effect of generating electrical power on tract beyond facility requirements and exporting the excess?

- What are the on-tract environmental effects of the alternative schemes?

The answers to these questions are summarized in Table 7.8-1 and further discussed in Subsection 7.8.8, "Selection Rationale."

The on-tract environmental effects are related very closely to the severity of upgrading. As the raw shale oil is refined more completely, increasing quantities of sulfur and nitrogen are removed from it and are recovered as elemental sulfur and ammonia, both useful chemical commodities.

As upgrading severity increases, so do the requirements for raw water and fuel for boilers and fired heaters. This is an effect and a cost that must be recognized as a part of shale oil recovery and refining.

With respect to the on-tract effects on air quality, significant environmental impacts may result from combustion of coke containing nitrogen to an extent that would cause NO_x emissions in the flue gas. There are no satisfactorily demonstrated large-scale technologies presently available for fully effective correction of the problem. These cases show up with black rectangles in the "Air" column in Table 7.8-1. In contrast, in other alternatives, the flue gases resulting from burning scrubbed fuel gases do not present such a problem.

Significant on-tract effects on water quality arise from coking and heavy-oil cracking process water streams that contain chemical compounds — such as phenols, cyanides, and other nonstrippable materials — that are very difficult to remove with existing technology. In Table 7.8-1, these are represented as black rectangles in the "Water" column. On the other hand, process water from other alternatives contains principally hydrogen sulfide and ammonia, and since both these compounds are easily strippable, the water can be reused.

No solids handling or disposal problems arise that cannot be controlled easily. This fact is especially apparent when these solids are compared with the large amounts of processed shale.

Table 7.8-1

ENVIRONMENTAL EFFECTS OF SHALE OIL UPGRADING SCHEMES

RGY EXPORT (c)		CUMULATIVE ENVIRONMENTAL EFFECTS ON TRACT (c)		
AM	ELECTRICITY	AIR	WATER	SOLID
	■	□	□	□
		□	□	□
		□	□	□
	■	▒	▒	□
		▒	▒	□
		▒	▒	□
	■	■	■	▒
		▒	■	▒
		▒	■	▒
	■	■	■	▒
		■	■	▒
		■	■	▒
		▒	▒	□
		▒	▒	□
		▒	▒	□
	■	■	■	▒
		▒	■	▒
		▒	■	▒
		▒	▒	□
		▒	▒	□
		▒	▒	□
	■	■	■	▒
		■	■	▒
		■	■	▒

(a) **FUEL QUALITY**

1. High-quality refine
2. Boiler fuel quality;
3. Cracked shale oil; s
4. Raw shale oil; high

(b) **ELECTRICAL GENER**

Option A. All surpl
Power in excess of that
Option B. The utili
for the oil shale facility
reliance on an outside
exported.
Option C. There is r
purchased. All surplus

(c) **LEGEND**

□ Minimal on-t
▒ Controllable
■ Significant e

(d) **FURTHER DISCOUN**

(e) **FURTHER ANALYSIS**

The on-tract environmental effects are related very closely to the severity of upgrading. As the raw shale oil is refined more completely, increasing quantities of sulfur and nitrogen are removed from it and are recovered as elemental sulfur and ammonia, both useful chemical commodities.

As upgrading severity increases, so do the requirements for raw water and fuel for boilers and fired heaters. This is an effect and a cost that must be recognized as a part of shale oil recovery and refining.

With respect to the on-tract effects on air quality, significant environmental impacts may result from combustion of coke containing nitrogen to an extent that would cause NO_x emissions in the flue gas. There are no satisfactorily demonstrated large-scale technologies presently available for fully effective correction of the problem. These cases show up with black rectangles in the "Air" column in Table 7.8-1. In contrast, in other alternatives, the flue gases resulting from burning scrubbed fuel gases do not present such a problem.

Significant on-tract effects on water quality arise from coking and heavy-oil cracking process water streams that contain chemical compounds — such as phenols, cyanides, and other nonstrippable materials — that are very difficult to remove with existing technology. In Table 7.8-1, these are represented as black rectangles in the "Water" column. On the other hand, process water from other alternatives contains principally hydrogen sulfide and ammonia, and since both these compounds are easily strippable, the water can be reused.

No solids handling or disposal problems arise that cannot be controlled easily. This fact is especially apparent when these solids are compared with the large amounts of processed shale.

Table 7.8-1

ENVIRONMENTAL EFFECTS OF SHALE OIL UPGRADING SCHEMES

ALTERNATIVE FUEL PROCESS QUALITY [a]	UPGRADING SCHEME		ELECTRICAL GENERATION OPTIONS [b]	ENERGY EXPORT [c]		CUMULATIVE ENVIRONMENTAL EFFECTS ON TRACT [c]		
				GAS/STEAM	ELECTRICITY	AIR	WATER	SOLID
4	None	RAW SHALE OIL	A[d]		■	□	□	□
			B	■		□	□	□
			C	■		□	□	□
3	Mild	VISBREAKING	A[d]		■	▩	▩	□
			B	■		▩	▩	□
			C	■		▩	▩	□
3		DELAYED COKING	A		■	■	■	▩
			B	■		▩	■	▩
			C	■		▩	■	▩
3		HEAVY OIL CRACKING HYDROSTABILIZATION	A		■	■	■	▩
			B	■		■	■	▩
			C	■		■	■	▩
2	Moderate	HYDROTREATING	A			▩	▩	□
			B			▩	▩	□
			C	■		▩	▩	□
1	Severe	DELAYED COKING HYDROTREATING	A		■	■	■	▩
			B			▩	■	▩
			C	■		▩	■	▩
1		SEVERE HYDROTREATING	A			▩	▩	□
			B			▩	▩	□
			C	■		▩	▩	□
1		HEAVY OIL CRACKING HYDROTREATING	A		■	■	■	▩
			B	■		■	■	▩
			C	■		■	■	▩

(a) **FUEL QUALITY**

1. High-quality refinery feedstock; lowest in nitrogen and sulfur
2. Boiler fuel quality, low in nitrogen and sulfur
3. Cracked shale oil, still high in nitrogen and sulfur, readily transported by pipeline
4. Raw shale oil; high in nitrogen and sulfur; not readily transported by pipeline

(b) **ELECTRICAL GENERATION OPTION**

Option A. All surplus fuel and steam are converted to electric power in a utility plant. Power in excess of that required for the oil shale facility is exported.

Option B. The utility plant is sized only large enough to satisfy the power requirements for the oil shale facility. The utility plant includes sufficient spare equipment to preclude reliance on an outside power source. Fuel in excess of that needed in the utility plant is exported.

Option C. There is no utility plant. The power required for the oil shale facility is purchased. All surplus fuel and steam are exported.

(c) **LEGEND**

□ Minimal on-tract effects

▩ Controllable to meet state and federal pollution control regulations

■ Significant environmental impacts or implications

(d) **FURTHER DISCOUNTED; REFER TO SUBSECTION 7.8.8.3**

(e) **FURTHER ANALYSIS IN SUBSECTION 7.8.8, "SELECTION RATIONALE"**

7.8.7 SUPPORT PROCESSES

These processes serve the essential purpose of separating the output streams of the primary processes described above into useful components and of removing contaminants (sulfur, nitrogen, and arsenic) from them for environmental protection. In general, these processes are proven, standard technologies with only very minor alternative features.

7.8.7.1 Light Ends Processing

In all of the alternatives, there are two basic types of process gas streams to be considered: a low-Btu gas to be used as fuel, and a high-Btu gas to be separated into fuel gas and liquid product. The two gas streams are processed separately.

7.8.7.2 Low-But Gas

Typically, this is gas from the vertical DH retort. It contains a high proportion of nitrogen, as well as small quantities of hydrogen sulfide and ammonia. These latter components are removed and recovered in a sequence of operations: water washing and passage through a sulfur removal unit such as a Stretford sulfur plant. The treated gas is suitable for use as a fuel since the resultant flue gas will meet the relevant federal and state regulatory requirements. For further discussion, see Section 4 of this DDP.

7.8.7.3 High-Btu Gas

Typically, this is gas from the IH retorts or from upgrading processes, such as visbreaking, coking, or cracking. It contains components that have specific use in the overall upgrading schemes, as well as quantities of sulfur compounds that must be removed. Usually an amine scrubbing process removes hydrogen sulfide and small quantities of carbon dioxide. The hydrogen sulfide is converted to elemental sulfur in a sulfur recovery plant, and the carbon dioxide is discarded to the atmosphere.

The remaining hydrocarbons are separated by absorption and distillation into components suitable for use as fuel, hydrogen plant feedstock, and as additions to the product oil stream.

7.8.7.4 Hydrogen Production

In those alternative upgrading schemes that use hydrogen to improve product oil quality, the required quantities of light hydrocarbons (preferably propane and butane) are passed through a bed of catalyst along with steam at elevated temperature and pressure. The alternative choices for this process relate to refinements in catalysts and in operating procedures.

7.8.7.5 Wastewater Treating

The wastewaters from contacting and scrubbing operations are treated for removal and recovery of contaminants by methods described fully in Sections 3.15, 4, and 7.15.

7.8.7.6 Sulfur

The Claus process is an alternative to the Stretford type process for sulfur recovery. The sulfur recovered in the Claus sulfur plant varies depending on the specific alternative upgrading scheme. It will be of marketable quality and could serve fertilizer and industrial purposes.

The sulfur recovered from treating low-Btu gas in a Stretford sulfur plant may be of lower quality than that recovered in a Claus plant. If no market outlets are available, it may be disposed of in an appropriate site on the tract.

7.8.7.7 Ammonia

Ammonia is recovered for those alternatives using hydrogen processing. It is of marketable quality and could serve the fertilizer industry. No ammonia is recovered in the other schemes because the quantities recoverable are not commercially significant.

7.8.7.8 Arsenic

The first step in almost any scheme for refining shale oil will be the removal of arsenic, because the high arsenic concentrations in shale oils will severely poison most of the catalysts used in refining. Arsenic removal is generally carried out in an atmosphere of hydrogen under pressure at intermediate temperatures (250 to 350C) in a fixed bed; a disposable adsorbent catalytically promotes the deposition of the arsenic in much the same way that other metals are deposited on hydroprocessing catalysts. The cost of satisfactory removal is currently estimated to range from 25 to 50 cents per barrel. Much more research is needed into the nature of the arsenic compounds in shale oils, possible mechanisms and better materials for removing these compounds, and better methods for the disposing of the spent adsorbent.

7.8.8 SELECTION RATIONALE

7.8.8.1 Gas/Steam Export Potential

There are ten alternative upgrading possibilities to be considered, with three electrical power generation choices for each. Of these 30 cases, about half involve export from the tract, or flaring, of significant quantities of gas (principally low-Btu gas) or steam. The quantities are much too large to flare without adverse effects on resource recovery, but are too small to be transported economically to any existing point of use. Thus, in the broadest sense, these 13 cases must be discounted because of poor use of an available resource. These cases are identified in Table 7.8-1 with a black box in the energy export column.

7.8.8.2 Electricity Export Potential

Of the remaining 11 cases, four (delayed coking and heavy oil cracking) are further penalized because of the on-tract effects of NO_x produced by combustion of coke using current combustion technology and the difficulty of reclaiming water for reuse.

7.8.8.3 Conclusions

Referring to Table 7.8-1, seven cases remain as potential choices. They are summarized in Table 7.8-2.

Table 7.8-2

POTENTIAL UPGRADING PROCESSES

Case Number	Upgrading Process	Electrical Generation Option[(a)]
1	Raw shale oil, no upgrading	A
2	Visbreaking	A
3	Hydrotreating (moderate)	A
4	Hydrotreating (moderate)	B
5	Delayed coking-hydrotreating	B
6	Hydrotreating (severe)	A
7	Hydrotreating (severe)	B

(a) See Subsection 7.5.6.1 for definitions.

At this time, the White River Shale Project has selected Case No. 1, which involves the least on-tract environmental effects. No on-tract upgrading is required, as the product can be transported by truck and heated or insulated pipeline. Upgrading will undoubtedly be performed off-tract at the same site where the treated product is further refined. Off-tract upgrading avoids adding another operation that would detract from the primary Phase I objectives and it also avoid adding more operating personnel. For the quantities of raw shale oil contemplated in Phase I, this is the most logical arrangement.

Nevertheless, in view of the pace of retorting and upgrading technology development, other alternatives could easily be given future consideration as candidates for the actual installation.

7.9 HANDLING OF EXCESS EXCAVATED MATERIALS

Through good engineering, excess excavated material will be avoided. If there are any small quantities of excess material, they will be disposed of in a landfill in an acceptable manner.

7.10 PROCESSED SHALE DISPOSAL

7.10.1 INTRODUCTION AND OVERVIEW

Whatever methods are used to mine and retort the oil shale, the resulting processed shale must be disposed of in an environmentally acceptable place and manner. This section discusses the most probable plan, the alternative disposal sites, fill plans, water and dust control systems, and revegetation programs for Phases I, II, and III.

Water management is especially important in connection with processed shale disposal. Approximately 5,300 acres of drainage to the White River (and, ultimately, to the Colorado River) could be affected by the project. An integrated system of water control and conveyance will be designed to accomplish the following goals:

- No contamination of natural waterways or underground aquifers
- Limited erosion of the terrain
- Maximum use of drainage water for revegetation and other project uses

The drainage features and control measures for various phases of the project will include dams, ditches, stabilizing techniques, seepage control measures, surface contouring, and revegetation.

7.10.2 CHARACTERISTICS OF PROCESSED SHALE

Three different types of processed shale will be produced. In the following discussion it has been assumed that processed shale from Tracts Ua and Ub will be similar to processed shale from Colorado. This assumption appears warranted on the basis of laboratory testing of Paraho DH retorting.

- Paraho DH Processed Shale. This will make up the bulk of the processed shale. It is expected to be a coarse, gravel-like substance, grey-to-black in color, that is dusty and easily crumbled. Data on the physical properties of Paraho DH processed shale are tabulated in Section 3.10.*

*Woodward-Clyde Consultants (Ref. 7-2).

- Tosco II Processed Shale. This has a small particle size (-35 mesh average). It is black in color and generally has a larger organic carbon content than Paraho DH shale because the Tosco II shale has not been subjected to a combustion process.

- Union B Processed Shale. The size of this shale is between the Tosco II and Paraho DH. The organic carbon load is expected to be similar to the Tosco II processed shale, since the Union B processed shale has not been subjected to combustion.

A compacted density of 85 pounds per cubic foot for processed shale has been selected as a working figure based on Woodward-Clyde tests and on expected compaction by heavy equipment and by the shale itself as the pile enlarges.

The nature of processed oil shale presents two problems to the environment: dust and disposal. Dust control is discussed briefly in this section and at length in Section 4.2. A sound disposal plan for the processed shale must provide not only adequate physical space to hold the approximately 933 million cubic yards expected over the expected life of the project, but it must ensure that salts and other undesirable substances do not contaminate groundwater or the White River. The completed pile will be revegetated to blend in with existing topography and to support the kinds and amounts of animal life that live there now. It is also desirable that the revegetation program begin early in the project and proceed on a continuous basis; this requirement influences the method of placing the shale.

7.10.3 POSSIBLE DISPOSAL SITES

Possible repositories for the processed shale include Southam Canyon (on and off tract), Evacuation Creek, Canyon "G," and underground disposal in the mine. The advantages and disadvantages of each are discussed in the following paragraphs.

7.10.3.1 Southam Canyon — Off Tract

The southern off-tract part of Southam Canyon was considered in combination with filling the remaining on-tract portion of the canyon. The advantages include gaining more space for disposal and eliminating the possibility of water accumulating in the canyon behind the shale pile. This would preclude the necessity of either building a dam behind the shale pile or sealing the southern slope. And it would allow more natural drainage to the White River. However, the lease stipulates that all waste material be disposed of within the tract boundaries. If legislation is enacted that permits off-tract use, the southern off-tract portion of Southam Canyon can be used for shale disposal.

7.10.3.2 Evacuation Creek

Evacuation Creek, which runs through Tract Ub from south to north, was considered as a processed shale disposal area, but it was found less desirable for several reasons:

- Only a small portion (5½ square miles) of this stream's 290 square mile watershed is within the tract. The large size of this watershed would require an extensive drainage control system.
- The creek has the potential for an on-tract disposal volume (to the ridge tops) of approximately 830 million cubic yards. To contain the entire 26-year production of processed shale, the canyon would have to be filled well above the ridge tops.
- The 100-foot-thick Bird's Nest Aquifer, which outcrops near the present creek bed, would be a continual source of leachate and would be in danger of contamination from salts in the processed shale.

7.10.3.3 Canyon "G"

Canyon "G" lies directly west of the processing area, as shown in Figure 7.10-1, and is considered as a disposal site for processed shale only from Phase I. Its 40 million cubic yard capacity would be more than adequate for the estimated 17½ million cubic yards resulting from Phase I,

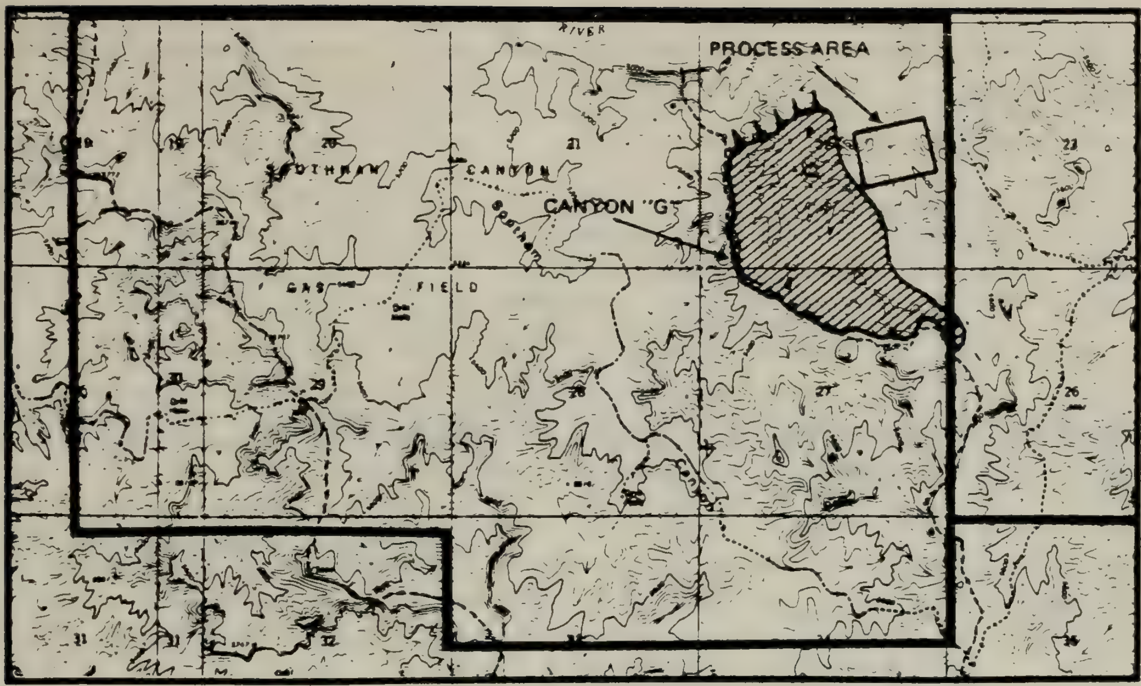


Figure 7.10-1 CANYON "G"

but it could not accommodate the shale from Phases II and III. The advantages of this site over Southam Canyon are its nearness to the processing area and its ability to serve as a temporary dump site if the conveyor fails in Southam Canyon. The disadvantage stems from having two separate processed shale piles if the project goes beyond Phase I.

7.10.3.4 Underground (Mine)

Underground disposal of processed shale is usually a more environmentally acceptable method than surface disposal. However, there are many technical problems that must be considered:

- The mine openings will only hold about 60 to 70 percent of the total, and therefore a significant portion of processed shale must be disposed of on the surface.

- Bureau of Mines test work shows that oil shale has a high coefficient of thermal expansion. Therefore, if hot processed shale is placed underground, it will tend to lower the vertical compressive strength of the support pillars, which could reduce the overall percent of ore recovery.

- Underground placement of processed shale into worked out panels is technically feasible, but it is more complex and much more costly than surface disposal. Dust is a major problem.

- With presently known methods, secondary recovery of the remaining support pillars and lower grade oil shale in the mine floor and roof, either by in-situ or conventional mining methods, would be extremely difficult if the underground openings were filled with processed shale.

The above problems need not preclude the possible eventual disposal of processed shale in the mine, but WRSP will proceed with surface disposal until the technical and economic viability of underground disposal is assured. WRSP will continue to evaluate this method of processed shale disposal as the leases are developed.

7.10.3.5 Southam Canyon — On Tract

The most probable plan calls for all processed shale to be placed on tract in Southam Canyon, which runs from south to north through Tract Ua. It has a small drainage area, and 4,050 acres of the 6,600-acre watershed lie within the tract. The canyon's total volume is approximately 1,400 million cubic yards, of which 940 million are on the tract. This is sufficient capacity to contain all the processed shale from all phases of the project.

Although the Bird's Nest Aquifer is found beneath Southam Canyon, it is confined and under artesian conditions. Drilling tests have shown relative impermeability of the material that overlies the aquifer; hence, neither significant upward migration of water nor significant downward migration of leachate is expected.

7.10.3.6 Evaluation and Selection

Southam Canyon on tract is the most probable choice for several reasons. It is big enough to contain all of the processed shale produced during the life of the project. The processed shale in Southam Canyon does not pose either a contamination danger to the Bird's Nest Aquifer or a problem in

providing drainage control facilities. Although there are no disadvantages to using Canyon "G" for the Phase I operation, it cannot be used for Phases II and III and does not possess any significant advantages over Southam Canyon, except for its convenient location.

7.10.4 PHASE I DISPOSAL

In the Phase I operation, the 26,700 TPSD of oil shale mined will yield approximately 20,225 TPSD of processed shale that must be disposed of. The disposal area must have a volume of approximately 17½ million cubic yards.

7.10.4.1 Fill Plan

The most probable plan calls for placing the processed shale from Phase I in a side canyon on the eastern ridge of Southam Canyon, as described in Section 3.10. A distinct advantage of this part of Southam Canyon is that it is a relatively small, discrete area that can be completely contained and revegetated if the project should stop after Phase I. If the project does continue into Phases II and III, the Southam Canyon Phase I area could be used both as a revegetation pilot station and as a beachhead for conveyors and for trucking activity.

7.10.4.2 Equipment

In the most probable plan, processed shale will be transported by partially covered conveyor from the retort to bins near the disposal site. There, it will be loaded onto trucks and moved to the final disposal area. The alternative is to replace the conveyors with trucks for the entire route. This is undesirable because of the increased emissions, dust, noise, energy consumption, labor costs, and generally greater environmental degradation.

7.10.4.3 Water Control and Management

The most probable plan, described in Section 3.10, calls for construction of a small catchment basin northwest of the shale pile to contain surface runoff from the pile. This catchment will be covered over in Phases II and III, as

described in Section 7.10. There are no real alternatives available for Phase I other than early construction of the Phase II/III catchment basins. If Canyon "G" were used, a catchment similar to the one described for a tributary of Southam Canyon would be required.

7.10.4.4 Dust Control

Dust control programs, detailed in Section 4.2, consist of enclosing conveyors and dust-generating points, wetting, and stabilization. Chemical wetting agents will be used only if necessary to minimize water consumption or to increase the surface stability of the processed shale.

7.10.4.5 Revegetation

The contouring and revegetation plan is described in Sections 3.10 and 4.6. Details of the program will include data developed during the ongoing research at Utah State University. The Phase I processed shale pile will be available for revegetation experimentation by Year 5, and the experience gained will influence the Phase II and III revegetation programs.

7.10.4.6 Fines Disposal

In Phase I, the most probable plan for the disposal of fines is to stockpile them for use in later phases. These fines will be processed for oil in Phase III. At the present time, the quantity of fines produced is expected to average 10 percent of the mined shale.

7.10.4.7 Evaluation and Selection

Phase I plans for shale disposal have few alternatives. There are only two possible sites, with little difference between them. Southam Canyon is preferred simply because it would form the beginning of an ongoing fill program. Possible alternative methods of handling and transporting the material are available, but their size and cost are inappropriate for Phase I.

The water control, dust control, and revegetation programs are all necessarily based on incomplete information and are subject to modification as

operating data become available from actual operation. These emerging programs will create more real alternatives to be evaluated for Phases II and III.

7.10.5 PHASE II AND III DISPOSAL

In Phase II, 95,700 TPSD of oil shale will be mined and in Phase III, 178,500 TPSD. The processed shale from these operations will total approximately 915.5 million cubic yards.

7.10.5.1 Fill Plan

Several procedures for filling Southam Canyon with processed shale have been proposed. The most probable plan is described in Section 3.10. The proposed plan calls for moving from the Phase I pile generally in a fanlike pattern to the south, west, and north.

Two other alternative fill plans evaluated were east-west berms and north-south ramps, with filling proceeding either from the north end of Southam Canyon to the south or vice versa. These are described below.

Starting at the North. In this disposal scheme, shown in Figure 7.10-2, a berm would be extended from east to west across the mouth of the canyon. The berm would have a 4:1, or 25 percent, compacted slope on its north face and a 5 percent slope on the south face and advancing front during building. The top of the berm would be 400 feet wide at an elevation of 5,500 feet. Southam Canyon would be filled to plateau level by a continual widening of this berm top in a southward direction, thus creating a continuous plateau rising with a 3 percent grade to approximately 5,760 feet. The surface would be contoured and revegetated as soon as possible after completion. The advantages are as follows:

- In approximately 5 years, the north slope could be completely established as a planting area, and more area would be continually available.

- Fewer resources would be required during initial phases of disposal work.

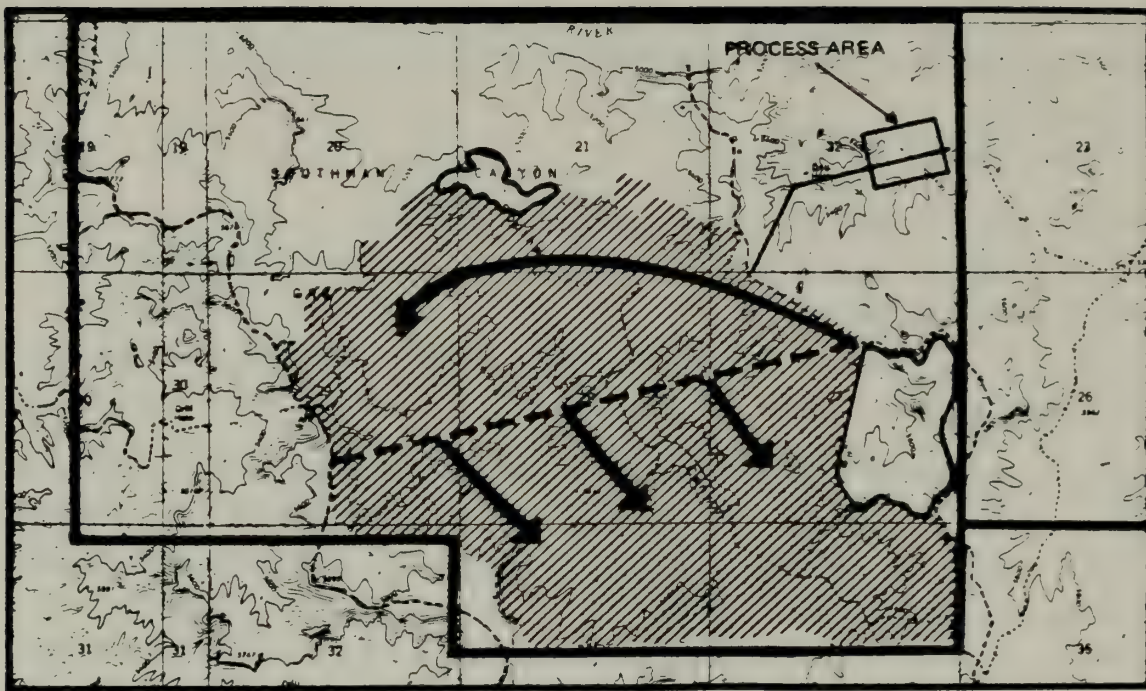


Figure 7.10-2 FILL PLAN STARTING AT THE NORTH

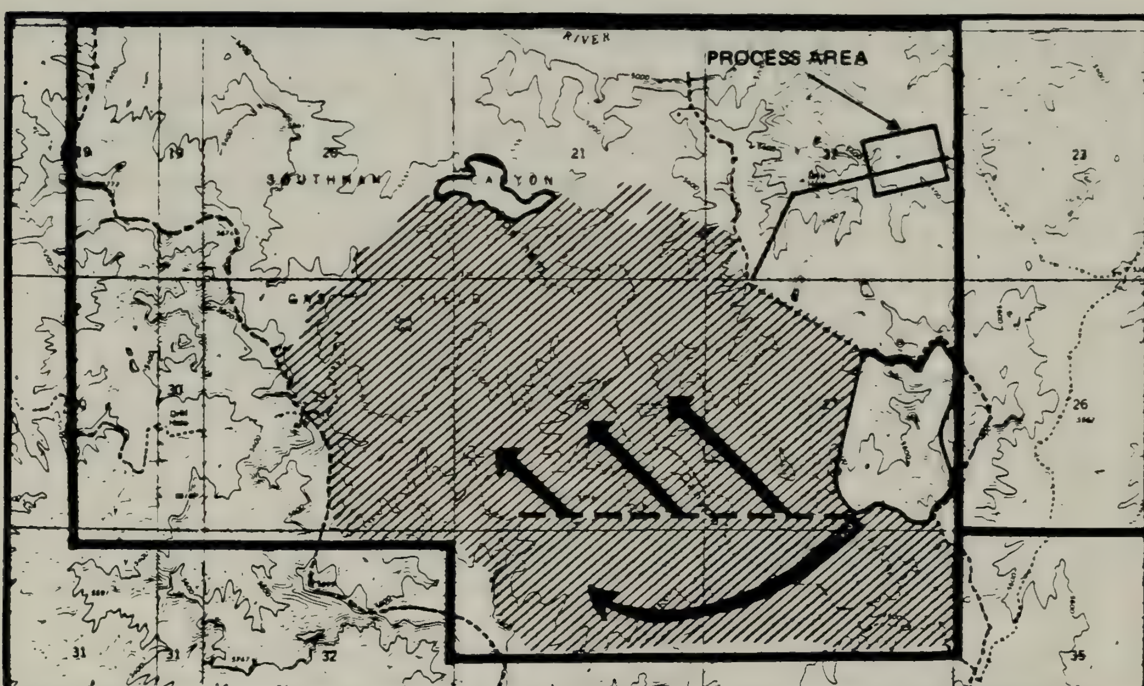


Figure 7.10-3 FILL PLAN STARTING AT THE SOUTH

The disadvantages are as follows:

- Since the canyon would be completely blocked off by the berm early in the project, storm runoff would collect in the canyon or percolate through the berm, carrying a high level of dissolved salts.
- At the time the 400-foot-wide berm is ready for revegetation, the area covered by processed shale would be up to a mile wide and 1½ miles long; i.e., approximately 900 acres would be disturbed before any significant revegetation could start.
- During the first 5 to 7 years, this scheme would allow the smallest ratio of vegetated to unvegetated shale area.

Starting at the South. In this disposal plan, illustrated in Figure 7.10-3, a ramp would be extended to the southeast tract limit. The filling would then proceed across the south end of the canyon, closing it off, and continue northward toward the mouth. When the northern boundary is reached, the pile would be compacted at a 4:1 slope.

The disadvantage of this method is that little area would become available for revegetation until the ramp was fully extended, which would require approximately 190 million cubic yards of material, or 5 years.

7.10.5.2 Equipment

Equipment for placing processed shale in Southam Canyon will be selected by balancing factors relating to the nature of the job and the characteristics of equipment alternatives available. The principal factors are:

- Rough terrain of Southam Canyon
- Compaction of processed shale — either by machine or by its own weight, or by both
- Reliability of equipment
- Environmental impacts

The means of transport investigated were conveyors, trucks, stackers, and slurry pipeline. Each is described and evaluated in the following paragraphs.

Conveyors. For the mass movement of processed shale from the retort area to Southam Canyon, covered conveyors are clearly superior to trucks and could possibly be replaced by a slurry transport system, as discussed later in this section.

After the shale arrives at Southam Canyon, it must be placed in the canyon. A system of fixed conveyors lacks the necessary flexibility for the final placing of the shale.

Trucks. For operations within Southam Canyon, trucks are a workable alternative. Trucks have the flexibility of movement required to place processed shale in the wide variety of side canyons and around the many natural obstacles encountered in the canyon.

Trucks have the added advantage of performing a degree of compaction during the placement of the shale. This reduces the need for specific compacting activities, which would contribute to the problems of dust, noise, and gaseous emissions.

Trucks have the disadvantage of high cost and limited load-carrying capacity relative to conveyor systems.

Stackers. A stacker is a very large mechanical device capable of receiving processed shale from a conveyor and tripper and transferring it to another conveyor that runs out on a long boom capable of swinging horizontally and vertically. The stacker mechanism, on crawler-mounted tracks, is itself capable of moving and maneuvering, but only in a limited fashion because of its great size and weight. Thus, a stacker permits the end of the conveyor to be moved while processed shale is being discharged.

One or more stackers could begin operation from the top of the pile formed in earlier stages of commercial operation. Terraced piles would be built cascading from top elevation down to the bottom of the canyon. Use of more than one stacker would permit continued operation during repair, maintenance, or moving of one of the stackers.

Auxiliary equipment (dozers, graders, trucks) is required with the use of stackers to shape the pile, to create finished contoured surface, and to construct ramps that will allow stackers to climb the terraces.

Stackers have the following advantages over trucks:

- Less exhaust fumes on tract because the stackers are powered by electricity
- Quieter operation than trucks
- Less congestion at loading points
- Fewer transfers of material — thus less dust
- More reliable operation in bad weather

Stackers have the following disadvantages:

- Requires auxiliary equipment for compacting and fine sculpturing in a separate operation from placement
- Not as well established as truck use in the U.S. — with consequent questions of reliability and maintenance

Stacker use during Phases II and III appears warranted due to the large volumes of material to be disposed of over a large area.

Slurry Pipeline. For this alternative, processed shale is converted into a slurry by mixing it with water, and the mix is then pumped through a pipeline to Southam Canyon. This scheme has some distinct advantages:

- There is no dust problem — at least during initial placement.
- The operation is quiet and flexible.

However, there are serious disadvantages:

- A large amount of water is required by the slurry process even though some of the water used in the transport is returned and reused.
- Saturating the shale creates a greater danger of groundwater contamination.
- The processed shale requires further crushing for slurry preparation, thus creating more dust in the crushing operation and augmenting the dust problem.

The overall operation, with its additional crushing, water recovery, increased water use, and potential dust problems, has been judged a less desirable alternative at this time.

7.10.5.3 Water Control Management

The present hydrologic conditions of the Southam Canyon disposal site are discussed in the following paragraphs, followed by proposed control methods. more comprehensive information about water resources for the entire lease area is found in Section 2.3.

Groundwater. In the disposal area, groundwater is present in a complex system of both shallow unconfined and deep confined aquifers. Shallow unconfined groundwater exists in the alluvium near the mouth of Southam Canyon and the White River flood plain. Spring 1975 observations found short-lived seeps from the bedding planes and fractures of the shale and siltstone of the Uinta Formation. However, onsite drilling encountered no water in the formation.

The Bird's Nest Aquifer, found in the upper part of the Green River Formation, is the aquifer of primary concern in the disposal area. Its thickness ranges from 90 to 200 feet and averages approximately 115 feet. Beneath Tract Ua, it is deeply buried under approximately 500 feet of interbedded sandstone and shale, and there are no known discharge points on the tract.

Data from the observation well program show that the Bird's Nest Aquifer dips to the northwest, as does the geologic structure.

The aquifer has been penetrated by 41 boreholes in Tracts Ua and Ub and yielded water to wells at rates ranging from 550 gpm near the northwest corner of Tract Ua to 3 gpm at the southern boundary of the project area.

Conditions for recharge are poor because annual rainfall amounts to approximately 9 inches, and the overlying, relatively impervious Uinta Formation restricts even that from reaching the aquifer. Evacuation Creek is a potential area for recharge where the aquifer is in contact with alluvium along some of the canyons.

Because of the physical characteristics of the processed shale disposal pile and the impermeability of the Uinta Formation, the Bird's Nest Aquifer is not expected to become contaminated by leachate from the processed shale materials.

Surface Runoff. In the most probable plan, a retention dam will be constructed near the mouth of Southam Canyon to prevent contaminated surface runoff from the shale pile from entering the White River. There is no practical alternative to this dam regardless of the fill plan used, and it must be built before Phase II begins.

Several alternatives to permitting temporary ponding of fresh water at a few locations off tract were examined and rejected because of their lower reliability, need for extensive maintenance, and increased exposure to possible contamination. The alternatives were:

- A small-diameter tunnel to divert the drainage south of the processed shale into the natural basin west of the site
- Conduits placed under the processed shale to transmit ponded water to the northern retention reservoir
- Permanent pumping systems to transfer the water to an adjacent natural drainage basin or freshwater basin

- A porous zone of crushed rock placed beneath the processed shale pile to allow percolation of impounded water along the natural drainage

As the revegetation program progresses in the later years of the program, most rainfall will be retained on the surface where it will either evaporate or be used by the vegetation. The predicted potential for evapotranspiration greatly exceeds the annual rainfall, providing an ideal means of water disposal.

As an alternative to retaining surface runoff on the processed shale pile, the surface of the pile could be graded to direct all runoff to the Southam Canyon Reservoir; however, this could create excessive erosion of the shale and inhibit the revegetation program.

7.10.5.4 Dust Control

Dust control measures will include the following:

- Wetting processed shale upon exit from retorts
- Scrubbing vent gas from moisturizers
- Enclosing conveyors
- Wetting shale at loadout bins as it is discharged both from conveyors and onto trucks
- Continuously maintaining truck haul routes by wetting and chemical stabilization techniques
- If necessary, wetting processed shale after spreading and compaction

The only alternative being considered is the possible addition of a chemical wetting agent if necessary. Dust control methods are discussed in detail in Section 4.2.

7.10.5.5 Revegetation

The lease stipulates that all disturbed areas be revegetated as quickly as possible to minimize leachate and stability problems, as well as for aesthetic reasons. A discussion of revegetation is contained in Section 4.6.

7.10.5.6 Evaluation and Selection

The most probable plan for Phases II and III is to place processed shale in Southam Canyon, on tract. The chosen fill plan begins from the Phase I pile, moves to the south, west, and north, and makes surface early and steadily available for revegetation. The main drainage pattern of Southam Canyon is not interfered with until the 10th year; contaminated runoff is contained by the Southam Canyon retention dam. Dust control and revegetation will be expanded versions of methods used in Phase I.

7.10.6 ABANDONMENT

When the commercial-grade oil shale has been mined out and the project is abandoned, several courses of action may be considered with regard to processed shale disposal, shale pile stabilization, and water impoundment.

Processed Shale Disposal. It has been suggested that processed shale be returned to the mine after project abandonment. This has several disadvantages: the problem of storing the shale until parts of the mine are exhausted and ready for refill, and, if the mine is filled, the unavailability of leaner shale and remaining pillars for mining if appropriate technologies are later developed. Because the shale expands in mining and handling, it could not all be returned to the mine. At present, this alternative is not considered practical.

Shale Pile Stabilization. The processed shale pile in Southam Canyon should be satisfactorily stabilized against undesirable erosion within 10 years after abandonment, depending upon climatic conditions. Stabilization will

be brought about by surface contouring and revegetation. After abandonment, the pile will be monitored to ensure that revegetation is progressing satisfactorily. When stable, no further attention should be required because the evapotranspiration greatly exceeds the annual rainfall. (Although this is true on an annual basis, short-duration high-intensity thunderstorms will result in surface runoff which will be contained by the contoured side slopes of the processed shale pile and retention dam.)

Water Impoundment. There are two possible problem areas: the Southam Canyon retention dam and the off-tract, southern part of Southam Canyon, near the south edge of the processed shale pile.

Additional information must be gathered during Phase I of the project to determine the following conditions and requirements at the retention dam:

- Characteristics of the impoundment
- Necessity for fencing
- Actual volume of sediment in the runoff to reevaluate the holding capacity of the reservoir
- Seepage

The retention dam will be designed to contain a 100-year storm. The potential evaporation is expected to exceed surface runoff during an average year. Most of the time, little or no water will be standing behind the dam.

Some storm runoff water may be trapped behind the shale pile in the southern part of Southam Canyon. The potential evaporation is expected to consume this volume of water during an average year.

7.11 SOLID WASTE DISPOSAL

This section describes the alternatives for solid waste disposal other than shale solids. Where possible, the advantages and disadvantages of each alternative are weighed and compared with the selection criteria, and the most probable case selected.

Three alternatives for solid waste disposal were considered:

- Landfill of nonhazardous wastes incorporated with processed shale disposal pile (proposed case)
- Landfill independent of processed shale disposal pile
- Combination of incineration and landfill

Hazardous wastes will be disposed of in accordance with the Resource Conservation and Recovery Act.

Many alternatives of solid waste collection and transport are possible. However, their differences with respect to technical, economic, and environmental selection criteria are considered to be minor, and therefore are not discussed.

Only a small portion of the solid wastes may be economically salvageable, and these will be salvaged when practical.

7.11.1 LANDFILL IN PROCESSED SHALE DISPOSAL AREA

In this alternative, non-hazardous solid wastes from construction and operation activities are deposited by landfill methods in the processed shale disposal area. Transport is by truck, by conveyor with the processed shale, or by a combination of these methods. During construction periods, the construction-related wastes are disposed of at a landfill site, which is later covered with processed shale. When processed shale is being

produced, non-hazardous solid wastes are layered in the processed shale. (Slurry wastes would be mixed uniformly with processed shale.) Overall, several small sites, all within the processed shale disposal area, will be involved. A separate disposal site will be developed on tract for the disposal of hazardous wastes. An alternative to this plan would be transport and disposal at a permitted hazardous waste disposal site.

7.11.2 SEPARATE LANDFILL

In this alternative, construction and operation wastes are collected and hauled by truck to landfill disposal sites that are separate from the processed shale disposal area but still on tract. The sites, such as an area about 1-1/2 miles northeast of the plant, are close to the plant, readily accessible, and away from any major drainage channel. Access roads and the sites are developed upon initiation of Phase II construction or sooner if necessary and are operated throughout the project life. All non-hazardous solid wastes are buried in the landfills. Suitable erosion, runoff, leachate, dust, and litter control procedures are employed to assure acceptable operation of the sites. The completed sections of these landfills are revegetated.

7.11.3 COMBINATION OF INCINERATION AND LANDFILL

In this alternative, all combustible solids are segregated and burned in an onsite incinerator. The remaining waste, along with the incineration ash, is disposed of in the processed shale disposal area as in the first alternative. The composition and the quantity of combustible waste will vary during the various phases of the project. Generally speaking, however, the combustible solid waste will be a small fraction of the total solid waste generated over the life of the project.

7.11.4 EVALUATION OF ALTERNATIVES

The three alternatives were evaluated according to major technical, environmental, and economic factors, and the results are given in Table 7.11-1. As indicated in this table, the proposed case of disposal in the processed shale pile has the lowest cost and the least impact on the environment, primarily because no additional land area will be disturbed.

Table 7.11-1

COMPARISON OF SOLID WASTE DISPOSAL ALTERNATIVES

Selection Criteria	Disposal Alternatives[a]		
	Landfill With Processed Shale	Separate Landfill	Incineration and Landfill
Technical Factors			
• Feasibility	Landfill is well suited to the changing WRSP waste loads and characteristics	Landfill is well suited to the changing WRSP waste loads and characteristics	Potential problems in design and operation of incinerator for changing waste loads and characteristics
Environmental Factors			
• Land area distrubed	No additional area[b]	70 acres	1 acre (incinerator)
• Air emissions	Small amount of dust from landfill area	Small amount of dust from landfill area	Small amount of dust from landfill area; incinerator flue gas pollutants
• Groundwater and surface water affected	No additional water affected	Potential contamination runoff, leachate control required	No additional water affected
• Revegetation	No additional revegetation needed[a]	70 acre disturbed area	No additional revegetation needed[a]
Economic Factors (Relative Costs)			
• Access, land and site preparation	Low (cost shared with processed shale disposal)	High (new road and site development required)	Moderate (incinerator site development)
• Equipment and manpower	Low (some shared with processed shale disposal)	Moderate (typical for industrial landfill)	Moderate/high (incineration expensive, significant landfill needed)
• Environmental control and monitoring	Low (minimum additional needed)[a]	High (independent erosion, runoff, leachate control, and monitoring needed)	Moderate (flue gas cleanup and emission monitoring needed)

(a) Hazardous wastes will be disposed of in accordance with the Resource Conservation and Recovery Act.
(b) In addition to that planned for processed shale disposal.

7.12 UTILITIES AND SUPPORT FACILITIES

The basic power and steam system selected for implementation is designed to consume all product gas to generate a maximum amount of electrical power while supplying heating and process steam requirements. The discharges of the steam turbines driving mechanical equipment will supply the 50 psig steam requirements. Excess electric power will be exported to the outside power grid.

7.12.1 ELECTRIC POWER SUPPLY

Three other alternatives were considered for meeting the electric power demands of the full-scale commercial project: constructing an on site power plant to consume only enough product gas to generate the required power; purchasing all the required power from an outside source; and purchasing only enough power to equal the monthly demand charge from the outside grid. A fourth alternative considered was gas turbine generation instead of steam generation.

7.12.1.1 Self-Sufficient On Tract

This alternative would consume only enough product gas to generate the required electric power; no power would be exported. Such a plant would not be dependent on an outside source of power, but would be connected to the outside grid to ensure a power supply during emergency, upset, or maintenance periods. This alternative has the disadvantage of wasting potential fuel, since excess product gas would have to be incinerated.

7.12.1.2 Totally Purchased Electric Power

Under this alternative, the White River Shale Project would purchase all the required electric power except for minor amounts to be supplied by emergency standby equipment. The total capital investment for the plant then would be considerably reduced. However, it would be necessary to incinerate the excess low-Btu gas, thus wasting potential fuel.

This loss of fuel for power generation would be reflected in increased plant operating cost through the purchase of outside power.

7.12.1.3 Partially Purchased Electric Power

Because the WRSP facilities will be connected to the external power grid, there will be a demand charge incurred for electric service even if no power is actually purchased. A third alternative is therefore possible: replacing some of the larger electric motors presently planned with steam turbine drivers, reducing the electrical demand, the associated demand charge, and the amount of power generated on site. The project would purchase only enough power to equal the monthly demand charge. This alternative will continue to be evaluated as negotiations with the external power suppliers proceed.

7.12.1.4 Gas-Turbine-Driven Generators

Multiple gas-turbine-driven generator sets could be used instead of the boiler/steam turbine cycles indicated in the proposed system defined in Section 3. Gas turbines fired directly on the excess process gas would reduce the need for much of the steam equipment. Savings in plot and powerhouse space would result, due to the deletion of boiler capacity and vacuum surface condensers. Gas turbines would not completely eliminate the need for steam generating capability as process and utility steam demands still exist. However, during normal operation, gas turbines may not require a supplemental fuel. Requirements for cooling water and raw water makeup rates could be reduced due to steam condensing requirements.

The overall thermal efficiency would probably be reduced. However, using the hot turbine exhaust gases in a waste heat boiler unit may result in a higher combined thermal efficiency than for the steam plant options discussed above.

Further study would be necessary to develop the direct fired gas turbine alternative.

7.12.2 STEAM REQUIREMENTS AND SUPPLY

Steam will be required in the various project facilities for process use, driving steam turbines, heating, and several miscellaneous purposes. This steam will be provided by on-site boilers fired by high- and low-Btu gases generated in the retorts.

7.12.2.1 Boiler Operating Pressures

Steam will be generated and used at several levels in the process units in accordance with prevailing conditions and requirements. The steam system in the process units will include headers at 600, 150, and 50 psig. Steam generated at the boiler house will be delivered to the power generation turbines at 1,500 psig, conditions more suitable for this service than the lower pressures of the process unit steam mains.

The power generation turbines will be arranged for steam extraction at 600 psig to provide steam needed for smaller turbine drivers used in process and off-site services. The extraction rate will be variable to allow an overall steam balance to be maintained.

The boiler design pressure will be 1,800 psig to allow a margin for operating pressure drop and for the increased pressure that will exist during possible relief valve discharge.

This plan may be altered if one of the electric power supply alternatives is selected for use. For example, if gas turbine drivers are used, or if total purchase of electric power is planned, the 1,500 psig steam service may be deleted.

7.12.2.2 Boiler Fuel Management

The Phase II and III boiler selection is based on consuming all product gases, as well as a supplemental fuel, as necessary to stabilize combustion. The boilers and turbo-generators are matched to the rate of process gas production to maximize the amount of energy extracted. If one or more of the boilers or turbo-generators should fail or be shut down, a part of the product gas would have to incinerated, since process units would continue to operate. A spare boiler is therefore an alternative that will continue to be evaluated in the future.

7.12.3 COOLING SYSTEMS

A means for disposing of waste heat is required in the design of the steam and electric power facilities associated with the project. It is presently planned to use water-cooled exchangers and condensers for this purpose. Two other alternatives were considered: direct air cooling and indirect air cooling. Both of these alternatives would result in lower consumptive water use, since evaporative losses would be eliminated. If water were to become scarce, use of these alternatives would be considered further, although they involve larger and more expensive condensers and coolers. In the case of indirect air cooling (air cooling of a closed-loop water system), cooling water flows, and therefore pumping costs, would be higher as well.

7.12.4 EVALUATION OF ALTERNATIVES

The choices proposed for the full-scale commercial plant have been made on the basis of overall economics and practicality, in addition to judgmental factors. Later, during the detailed engineering design of the plant, these alternatives will be reexamined. Several factors may affect the evaluation of steam and electric power alternatives, including such items as the outcome of negotiations with outside electric utilities, changes in steam and power requirements, and changes in water supply.

If outside electric power is finally available at a low cost, there could be an economically feasible alternative based on buying substantially all of the needed electric power, and incinerating a considerable volume of excess low-Btu gas. This alternative probably could not be given serious consideration because of the attendant energy waste.

A combined-cycle power plant might be devised to reduce the use of supplemental fuel. At present, such a design would seem to require the development of gas turbines capable of firing low-Btu gas or fuel mixtures containing some percentage of this gas. In the detail design of the plant, such possible improvements in efficiency will be given careful attention.

7.13 ANCILLARY FACILITIES AND MAINTENANCE

7.13.1 DRAINAGE SYSTEM

The intent of the drainage plan incorporated into the project facilities is to maximize the use of natural drainage courses for stream runoff while retaining contaminants and preventing erosion as a result of project activities.

Erosion, drainage, and contaminant control are accomplished with ditches, surface grading, revegetation, stabilizing techniques, and dam impoundments. Plant site facilities to prevent contaminated drainage flows from reaching the White River are:

- Phase I processed shale catchment dam
- Phase I fines stockpile embankments
- Southam Canyon retention dam, Phases II and III
- Wastewater and storm runoff holding basin

The Southam Canyon dams are discussed elsewhere in this report. The facilities considered in this section relate to wastewater and storm runoff from the process area. These include the oily water sewer system, the storm sewer system, and the sanitary sewer system.

The wastewater and storm sewer systems are similar to those used in essentially all major industrial plants handling chemicals and hydrocarbons. Since the alternative procedures and equipment for dealing with these matters have been investigated, evaluated, and standardized to a significant degree, the range of alternatives considered has been restricted essentially to modest variations.

7.13.2 PLANT SEWER SYSTEMS

The drainage systems for the main plant area consist of oily water sewers, storm sewers, and sanitary sewers. The purposes of these systems are as follows:

- Oily Water Sewer System
  - Achieve economical collection of all wastewaters contaminated by oils
  - Provide a means of removing flammable liquid spills quickly from operating and hazardous areas
  - Provide a means of controlling fire spread in an area by limiting surface propagation of fires from liquid carryover from one area to another
- Storm Sewer System
  - Economically collect and convey surface runoff uncontaminated by hydrocarbons and other pollutants
  - Intercept and collect uncontaminated runoff to minimize flows of waste streams through treatment facilities
  - Minimize chances of collecting accidentally contaminated waters, which would necessitate treatment not normally given to these flows
- Sanitary Sewer System
  - Provide an efficient means for collecting all sanitary wastes for conveyance to the treatment plant
  - Minimize flows through the treatment system by eliminating sources of flows not requiring treatment as sanitary wastes

All three systems are segregated, and their flows are treated separately. The oily waste stream and sanitary sewage are treated in the same waste treatment plant but by different procedures. The storm runoff collected by the storm drain system is routed through an API separator where any oily waste accidentally picked up in the stream is separated and recovered before the runoff is used as low-TDS makeup water.

7.13.2.1 Oily Water Sewers

The selected alternative consists of an oily water sewer system draining the operating process areas that are subject to oil contamination. To permit washdown of oily wastes into the system, the surfaces in the area are paved and impervious. All storm runoff and fire-fighting water in these areas is collected in this system. All lines are liquid-sealed against propagation of flammable vapors from one operating area to another. Surfaces are sloped to prevent hydrocarbon liquid flowing from one operating area to another. All manholes in hazardous areas have vapor-tight lids with vents discharging in safe areas.

7.13.2.2 Storm Sewers

The selected system collects all runoff from areas not normally subject to hydrocarbon contamination. The runoff from these areas is collected primarily by a ditch and culvert system. Storm runoff in the diked tankage area is stored behind the dikes for the duration of a storm. The water is drained to the storm sewer system after large storms, but it is left to evaporate behind the dikes after minor storms. The storm sewer system channels all of the foregoing runoff through an API separator into the holding basin, which is located to collect all runoff otherwise intercepted in the drainage basin containing all plant facilities.

7.13.2.3 Sanitary Sewers

The system collects only sanitary sewage from all sources within the plant drainage basin, and routes this sewage to the waste treatment plant. Minor pretreatment, such as grease separation at the cafeteria, is provided prior to treating in the waste treatment plant. Provisions may include a floating solids separation unit (septic tank) at all facilities generating sanitary wastes. The effluent will be chlorinated and discharged into the oily water sewwer system, which will then be a combined system conveying flow to the waste treatment plant. This system requires that the combined flow be treated for oil separation and removal as well as for sanitary sewage stabilization.

7.14 WATER SUPPLY FACILITIES

When preparing the initial feasibility study for the project, WRSP adopted the principle of a facility design based on the availability of water from the proposed White River Dam and maximum reuse of wastewaters. The latter was done because of the obviously high relative value of water in southern Uintah County.

Table 7.14-1 shows the ultimate water requirements (Phase III). (A water balance for Phases II and III is shown in Figure 3.15-3.) These requirements are based on detailed calculations and illustrate the principles of water conservation that will be employed in the final design.

There are, however, many variables that can affect water consumption, and most of these will increase the total water requirement. For example:

- There is a wide variation in water required for cooling, dust suppression, and compaction of the processed shale resulting from the various retorting systems. The actual water use for these purposes will depend on the final selected retorting system and operating experience.

- Regardless of the selected retorting system, the water requirements shown for an acceptable degree of dust control and shale compaction are only estimates and could well be higher.

- There is a substantial tradeoff between water use and energy production in the design of the cooling systems for the plant.

The water requirements for Phase III will total about 27,100 acre-feet per year.

Table 7.14-1

PHASE III WATER REQUIREMENTS*(a)

Use	Annual Average	
	Gallons per Minute	Acre-Feet per Year
Cooling Tower Evaporation	11,180	18,050
Shale Quenching and Dust Control	5,000	8,050
Other Miscellaneous Losses including Evaporation	627	1,000
Total	16,807	27,100

(a) Dry year basis. No allowance for annual rainfall.

7.14.1 WATER SUPPLY DEVELOPMENT PROGRAM

Providing water for the development of oil shale in eastern Utah, as well as serving other essential uses, is a matter of obvious importance. This subject has been studied and reported on by Bingham Engineering of Bountiful, Utah (Ref. 7-3). The material on water supply development has been abstracted from their report.

7.14.1.1 White River Dam

The preferred alternative is a proposed dam and reservoir on the White River, with related pumping facilities for delivery of water to Tracts Ua and Ub. This dam would be a multi-purpose development that would provide a reliable water supply for oil shale processing on these tracts, with a capacity sufficient to furnish water for additional oil shale developments in the area.

Several alternatives for providing water were studied in addition to the White River Dam (Ref. 7-4). These are briefly described below.

7.14.1.2 Green River Plan

Water released from the Flaming Gorge Reservoir would be pumped from the Green River at a point northwest of Bonanza. About 34 miles of 38-inch pipeline would be required to deliver water to the lease tracts, with pumping facilities required to lift water about 1,200 feet.

7.14.1.3 Starvation Reservoir Plan

Water would be released from Starvation Reservoir on an interim basis until required by the Central Utah Project. The water would be allowed to flow down the Duchesne River to serve as replacement water for that pumped from the Green River just above the Duchesne River confluence.

7.14.1.4 Red Fleet Reservoir Plan

This plan calls for conveying water from the Red Fleet Reservoir on Big Brush Creek. The project would make available only 8,000 acre-feet of water per year.

7.14.1.5 Watson Reservoir Plan

This plan calls for construction of a major water storage facility on the White River, with the dam located about 2-1/2 miles upstream from the old Ignatio Stage Stop. The dam would create a reservoir of about 102,000 acre-feet that would back water into Colorado. Water would be released from the reservoir into the White River, and from there it would be pumped to meet the project requiremeent.

7.14.1.6 Hells Hole Canyon Reservoir Plan

Under this plan, a 25,000 acre-foot offstream reservoir would be constructed in Hells Hole Canyon, a small tributary to the White River near the proposed Watson Dam. Water would be pumped from the White River into the reservoir created by a dam. It would then be pumped from the reservoir. The offstream site has the advantage of alleviating the sediment problem inherent in a main stream reservoir.

7.14.1.7 Bird's Nest Aquifer Plan

Water would be pumped from the Bird's Nest Aquifer to supply project development requirements. This plan has several disadvantages:

- Water is not available in sufficient quantity. Well pump tests showed only one well on the north edge of Tract Ua containing significant quantities of water.
- Water is of poor quality, containing high concentrations of dissolved solids.
- Insufficient recharge exists to provide significant quantities of water without depleting the resource.
- The water supply system would be very complex, requiring many wells, pumps, and pipelines, as well as a large degree of treatment.

7.14.1.8 Douglas Creek Member Plan

Water would be pumped from the Douglas Creek Member to supply project development requirements. This plan has several disadvantages:

- Available quantities of water appear to be very low, on the order of 10 gallons per minute yield.
- Water is of poor quality, although probably better than that of the Bird's Nest Aquifer.

- Insufficient recharge exists to supply water needs without excessive drawdown and mining of groundwater resources.

- The water supply system would be very complex, involving pumping from depths of 2,000 feet, a large number of wells, pumps, and pipelines, and a high degree of treatment.

7.14.1.9 Other Alternatives

Additional water sources were examined on a reconnaissance level to satisfy the potential requirements for oil shale development.

The first of these is to pipe water from Starvation Reservoir to the oil shale tracts. While no economic comparisons are available for this alternative, its cost appears to be excessive simply because of the long pipeline required (about 62 miles).

The second alternative requires construction of several small reservoirs on the upper tributaries of Willow Creek some 30 to 35 miles southwest of the oil shale lease tracts. Delivery of this water to the White River Shale Project would require an extensive network of tunnels, canals, and pipelines, and the cost appears to be prohibitive at this time.

7.14.2 EVALUATION OF ALTERNATIVES

From these alternatives, two were selected for more detailed study: The Green River Plan and the White River Plan, as shown in Figure 7.14-1. The preferred alternative is the White River dam and reservoir.

The Green River alternative is a single-purpose pipeline with the appurtenant pumping facilities to deliver water that has been released to the Green River from storage in Flaming Gorge Reservoir. This alternative would have a minimal environmental impact: water would be supplied through an existing storage facility; water flows in the Green River would not be

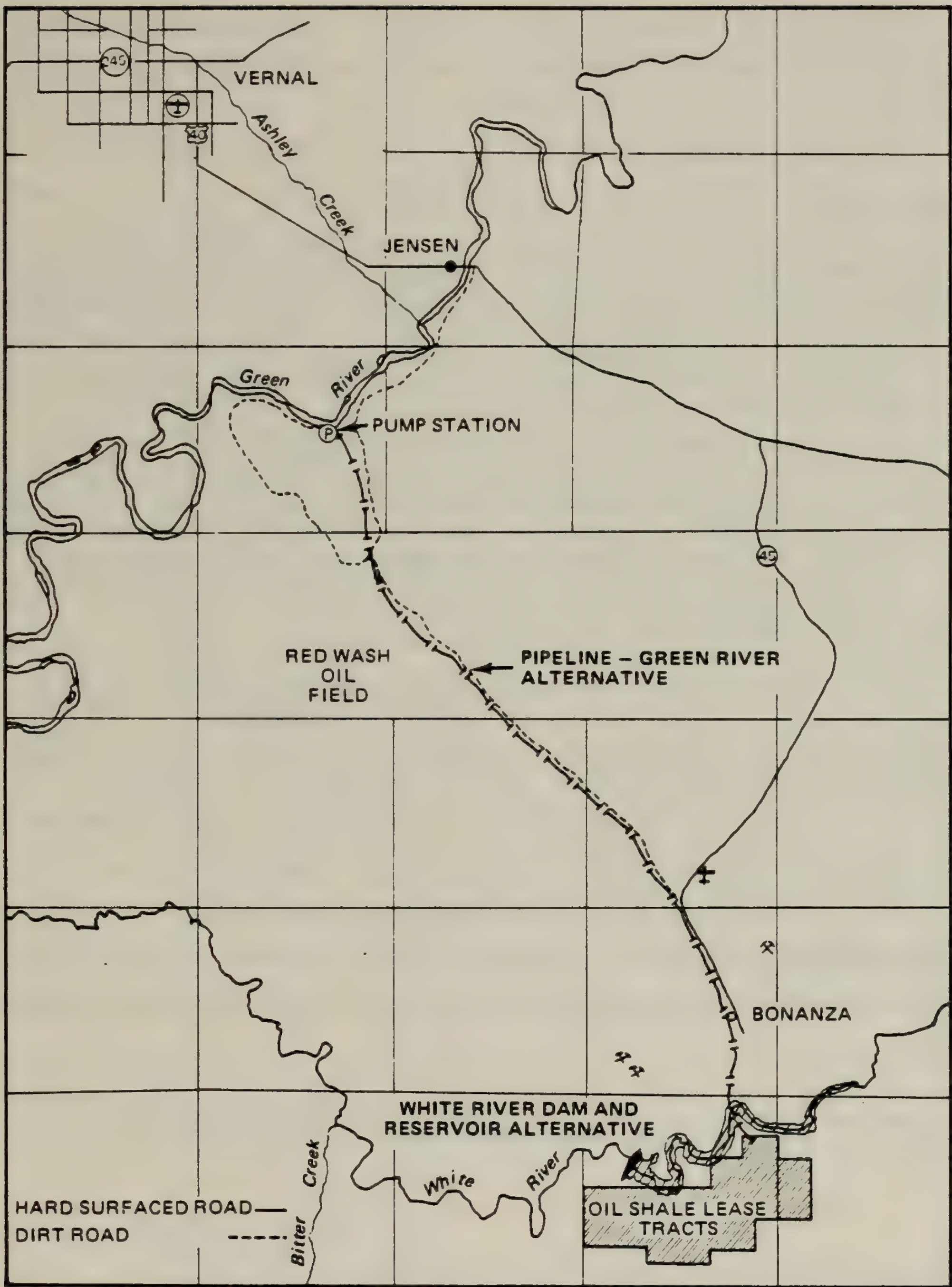


Figure 7.14-1 ALTERNATIVE WATER SOURCES

significantly altered; the pumping facilities would require a relatively small amount of land; and the pipeline would be buried and largely hidden from view. The principal adverse impacts appear to be the greater amount of energy required to operate the pumping facilities and the higher cost of the pipeline.

7.14.3 WATER RIGHTS

The U.S. Water and Power Resource Service (WPRS) has available approximately 500,000 acre-feet of water annually in storage in Flaming Gorge Reservoir. The WPRS has indicated a willingness to release water down the Green River so that it could be picked up and pumped to oil shale lease Tracts Ua and Ub and used for oil shale processing. Discussions held with WPRS personnel indicate that this raw water could be purchased and delivered to the Green River pump station. The WPRS suggested that the material contained in one of its 1974 publications (Ref. 7-4) can be construed as its commitment to supply water from Flaming Gorge Reservoir.

As discussed in Subsection 3.14.1.4, it appears reasonable that the quantity of water required could be made available to the White River Shale Project.

7.14.4 RAW WATER DELIVERY SYSTEM

7.14.4.1 White River Dam

The proposed water supply facilities for Phase II and III of the project consist of:

- A pumping station located on the south bank of the reservoir on the White River
- A 1.7 mile pipeline from the pumping station
- An on-tract storage pond at the terminal end of the pipeline

The Phase III water requirements are as shown in Table 7.14-1.

Raw water for the plant and processed shale uses will be pumped from the White River Reservoir through a 24-inch-diameter pipeline. The pumping station at the reservoir will be a fully enclosed structure housing screened intakes, pumps, motors, electrical switchgear, and mechanical systems. The pumps will be capable of pumping the average water requirement, with allowance in capacity for peak demands. Supervisory and telemetering equipment will be included to provide full remote control from the process plant control room. The power supply for the pumping station will be provided from the White River Shale Project power plant.

The on-tract storage pond will be constructed to provide operational flexibility and 3 days of reserve storage of 210 acre-feet to maintain a reliable supply of water during an outage of the reservoir pumping station or pipeline. Although no subsurface exploration or material testing has been performed, it is projected that the pond will be formed by an earthfill dam. In the construction of this dam, maximum use will be made of local materials.

An outlet system will distribute water from the pond to the plant and to the processed shale disposal area. This system will permit the flow to be synchronized for delivery to the plant, the processed shale area, or both. The average plant demand and the processed shale moisture control requirement will be delivered by gravity from the storage pond to the raw water treatment area, and then pumped to the ultimate water use point.

All pipelines will be buried below the frost depth for freeze protection and will be protected against corrosion, as required.

7.14.4.2 Green River Plan

In this alternative, the water supply facilities consist of the following:

- A pumping station located on the south bank of the Green River, southeast of Vernal.
- A 34 mile pipeline from the pumping station to the on-tract storage pond
- A distribution system from the storage pond, and other features similar to those described in Section 3.14

The average water requirement will be pumped in a single lift, or in multiple lifts if studies show it to be economically more feasible; it will flow through a steel pipeline of about 38 inches installed within the utility corridors following State Routes 264 and 45 to the southeast. The pipeline will cross the White River at the Highway Bridge near the Ignatio Stage Stop and will discharge into the on-tract storage pond. The pumping station will consist of a fully enclosed structure housing traveling screens, vertical turbine pumps, motors, electrical switch-gear, and mechanical systems. Supervisory and telemetering equipment will also be included to provide full remote control from the process plant control room. The power supply for the pumping plant will be provided from the existing 69 kV transmission line.

The storage pond and the distribution system to the plant and the processed shale area will be as described for the water supply facilities developed for the White River source, during both construction and operational phases.

7.14.5 WATER TREATMENT

The U.S. Geological Survey record (Ref. 7-5) indicates that the water quality of the Green River is similar to that of the White River. The two rivers have approximately the same turbidity, total dissolved solids, alkalinity, silica, and hardness contents, and will require the same level of treatment for the White River Shale Project use.

Several equipment suppliers can be used, but the concept of the overall treatment system (Section 3.14) will be the same regardless of the equipment, and the difference in the cost, if any, between alternative suppliers will be insignificant.

Selection of the raw water source between the White River and the Green River will be based on availability, the cost, and the environmental impact of the supply system, and not on treatment requirements.

7.14.6 SELECTION RATIONALE

The comparison of the two alternatives selected for close consideration is a difficult one because one of the two proposals (White River Dam) serves more than the single purpose of supplying water to the White River Shale Project; it is therefore being discussed in the state of Utah by parties directly interested in and affected by the potential White River Dam. The preference for the White River Dam, as expressed in the most probable plan, is based on its close proximity to the leases, the multiple benefits resulting from the dam, the geological competence of the dam site, the efficiency of the reservoir, and a lower cost.

7.15 WASTEWATER MANAGEMENT PLAN ALTERNATIVES

Selection of the most probable wastewater management plan is governed by the following objectives:

- Eliminate wastewater discharges to receiving streams
- Reuse the wastewater whenever practicable
- Conform to all applicable rules and regulations
- Prevent hazards to public health and safety
- Minimize adverse environmental impacts
- Select the most economical treatment systems

In addition, the selection depends on the quality and quantity of wastewater, on the water reuse potential, and on discharge limitations.

Wastewater management plan alternatives are presented in this section, along with the selection rationale behind the proposed action. The sources, expected flow rates, and characteristics of wastewaters are presented in Section 3.15.

7.15.1 COLLECTION ALTERNATIVES

The following wastewater collection alternatives are based on the level of stream segregation required:

- <u>Alternative A — No Segregation</u>. All wastewater streams are collected and discharged into the treatment facilities through one sewer network.
- <u>Alternative B — Minor Segregation</u>. Streams are segregated to a lesser degree than those in Alternative C, but through more than a single sewer.
- <u>Alternative C — Major Segregation</u>. Streams that are compatible in quality and in flow pattern are collected through the same network and discharged separately into the treatment facilities.

To achieve the wastewater management plan objectives, wastewaters should be collected in a way that permits optimization of their treatment and reuse. This would require major stream segregation according to type and level of contamination. Accordingly, Alternative C was selected.

The collected major streams are:

- High-TDS wastewater from boilers, cooling towers, and boiler feedwater treatment
- Sour water from the process units
- Oily washdown streams from main process plant area
- Sanitary wastewater from employee facilities
- Storm water runoff from contaminated and potentially contaminated areas

7.15.2 TREATMENT ALTERNATIVES

The degree to which wastewater streams need to be segregated depends primarily on the required treatment, which in turn depends on the intended reuse. The plans are to reuse all the wastewater streams as makeup to the scrubber for the secondary crushers. (Alternative water reuse schemes are discussed in Section 7.15.3)

The treatment alternatives discussed below for each of the wastewater streams were evaluated for the possibility of reusing all the wastewater and eliminating any discharge to natural water bodies.

7.15.2.1 High-TDS Wastewater

Treatment of this stream emphasizes inorganic salts removal. The alternatives include:

- Alternative A — No Treatment. The stream is reused directly as makeup to the secondary crusher scrubbers without receiving any treatment.

- Alternative B — Inorganics Removal. The salts are concentrated by a membrane process (reverse osmosis, electrodialysis) or through one of several alternative processes. The two "products" of such processes are brine and low-TDS water. The brine is used as makeup to the secondary crusher scrubbers and the low-TDS stream is used as process water.

Presently, the estimated makeup needs of the secondary crusher scrubbers exceed the total projected wastewater flows. Since the scrubber water need not be desalted, inorganic removal is not necessary. Accordingly, Alternative A was selected.

7.15.2.2 Sour Water

Alternatives for treatment of the sour water include:

- Alternative A — No Treatment. The stream is not treated.

- Alternative B — Steam Stripping. The stream is steam stripped only.

- Alternative C — Additional Treatment. The stream is stripped and then subjected to flotation and biological oxidation.

Alternative C was selected for treatment of sour water because of health hazards and nuisance considerations, and because the stripped sour water quality satisfies the reuse application.

7.15.2.3 Plant Washdown

The treatment alternatives are:

- Alternative A — Conventional Treatment. The stream is subjected to surge attenuation, followed by gravity separation of suspended solids.

- Alternative B — Additional Treatment. The stream is treated as in Alternative A and then subjected to flotation and biological oxidation.

The reuse application warrants treatment beyond surge attenuation and gross suspended solids and oil removal. Accordingly, Alternative B was selected.

7.15.2.4 Sanitary Wastewater

Possible alternatives for the sanitary wastewater treatment include:

- Alternative A — Minimum Treatment. The stream is chlorinated only.
- Alternative B — Conventional Treatment. The stream is chlorinated after treatment through sedimentation plus a biological oxidation process.
- Alternative C — Advanced Treatment. The stream is treated as in Alternative B, with the addition of a residual organics removal process (e.g., carbon adsorption).

Alternative A is not acceptable because biological treatment is necessary to prevent health hazards and nuisances (e.g., odor, coloration, algal stimulation). Alternative C is not warranted in view of the planned reuse. Consequently, Alternative B was selected.

7.15.2.5 Contaminated Runoff

The contaminated runoff alternatives are:

- Alternative A — No Treatment. The stream is reused without treatment.
- Alternative B — Solids Removal. The stream is reused after treatment to remove floatable and settlable solids.

To minimize nuisance, hazards to humans and wildlife, and sediment loading of the ponds, Alternative B was selected.

7.15.3 REUSE ALTERNATIVES

One of the primary objectives of the wastewater management plan is to have zero discharge. This will be achieved through the reuse of all the wastewater generated. Two main alternative reuse schemes were considered:

- Alternative A — Scrubber Makeup. The wastewater is used totally for makeup to the secondary crusher scrubbers, and then for wetting the processed shale.

- Alternative B — Scrubber and Cooling Tower Makeup. Part of the wastewater (high TDS) is used as makeup to the scrubbers, and the remaining part (low TDS) is used as cooling tower makeup.

Alternative A was selected because the use of wastewater as cooling tower makeup would necessitate, at the very least, biological oxidation treatment and filtration (whereas its use as scrubber makeup does not), and because the scrubber demands exceed the total wastewater flow.

However, this scheme assumes that mine water production is insignificant. If mine water (which is expected to contain a high concentration of inorganic salts) is encountered, the following alternatives would be considered, and the one that best satisfies the no-discharge objective would be selected.

- Alternative A — Moderate Mine Water Production. If there is a moderate production of mine water, the mine water, along with the high-TDS streams, would be used for dust control inside the mine and as the scrubber makeup. The low-TDS streams would then be treated further in a biological oxidation system and then filtered before reuse as part of the cooling tower makeup.

- Alternative B — High Mine Water Production. For high mine water production, if the mine water production rate exceeds the sum of the requirements for dust control, processed shale wetting, and scrubber demand, then a portion of the water would have to be desalted. The desalted stream would be used as part of the plant fresh water supply (process use only). The fresh water intake and net wastewater production rates would be reduced accordingly.

A graphic presentation of the proposed plan and these two alternatives is shown in Figure 7.15-1.

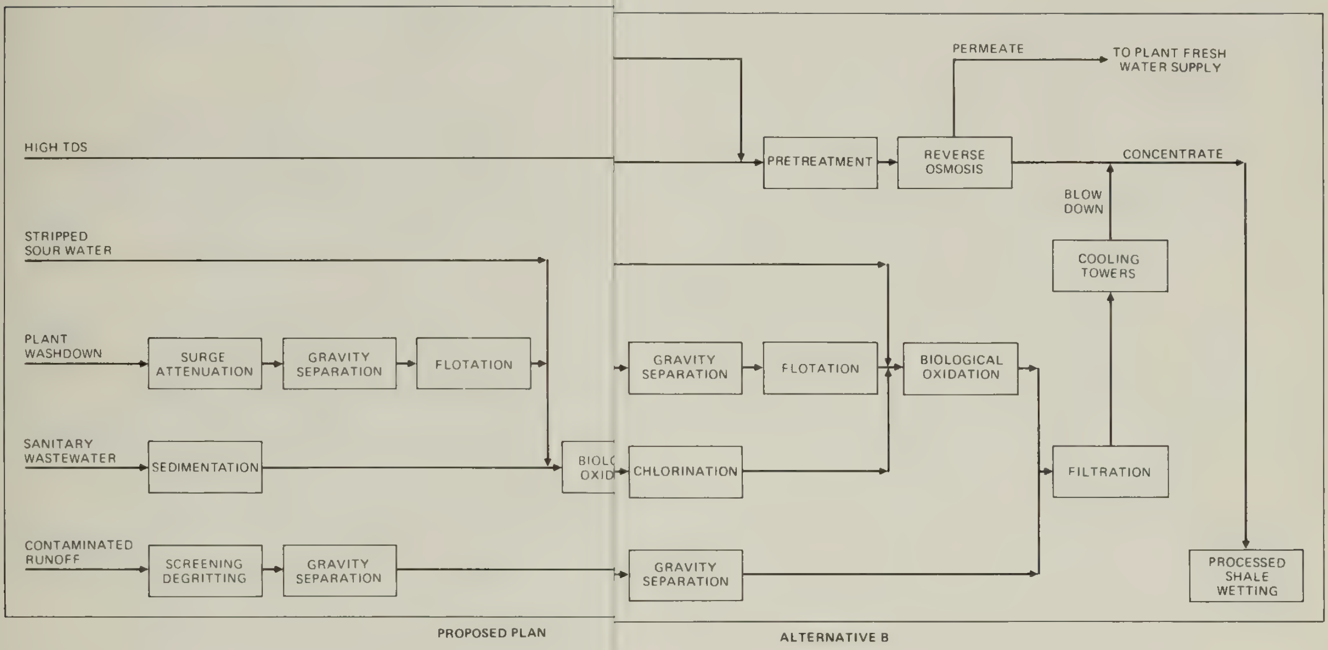


Figure 7.15-1 WASTEWATER REUSE ALTERNATIVES

- Alternative A — Scrubber Makeup. The wastewater is used totally for makeup to the secondary crusher scrubbers, and then for wetting the processed shale.

- Alternative B — Scrubber and Cooling Tower Makeup. Part of the wastewater (high TDS) is used as makeup to the scrubbers, and the remaining part (low TDS) is used as cooling tower makeup.

Alternative A was selected because the use of wastewater as cooling tower makeup would necessitate, at the very least, biological oxidation treatment and filtration (whereas its use as scrubber makeup does not), and because the scrubber demands exceed the total wastewater flow.

However, this scheme assumes that mine water production is insignificant. If mine water (which is expected to contain a high concentration of inorganic salts) is encountered, the following alternatives would be considered, and the one that best satisfies the no-discharge objective would be selected.

- Alternative A — Moderate Mine Water Production. If there is a moderate production of mine water, the mine water, along with the high-TDS streams, would be used for dust control inside the mine and as the scrubber makeup. The low-TDS streams would then be treated further in a biological oxidation system and then filtered before reuse as part of the cooling tower makeup.

- Alternative B — High Mine Water Production. For high mine water production, if the mine water production rate exceeds the sum of the requirements for dust control, processed shale wetting, and scrubber demand, then a portion of the water would have to be desalted. The desalted stream would be used as part of the plant fresh water supply (process use only). The fresh water intake and net wastewater production rates would be reduced accordingly.

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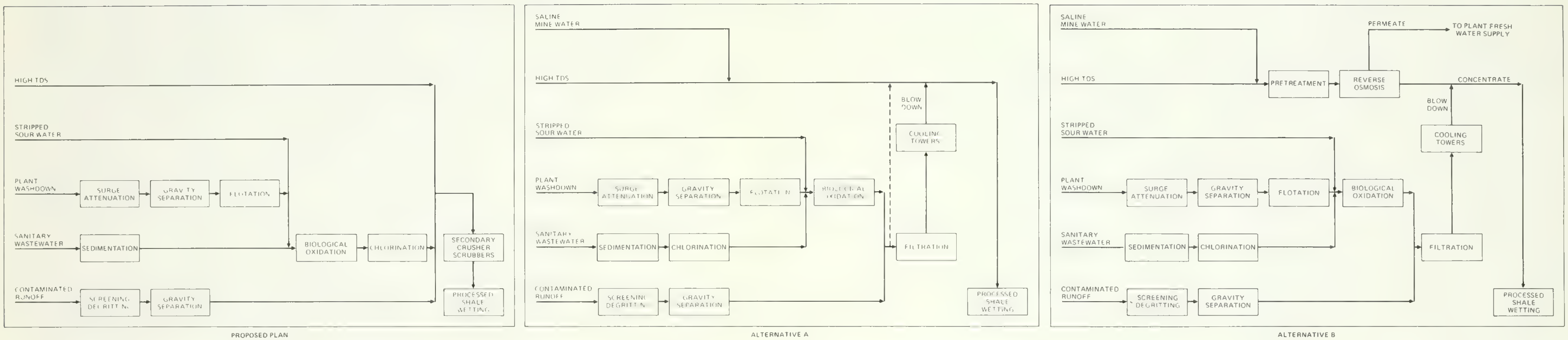

Figure 7.15-1 WASTEWATER REUSE ALTERNATIVES

7.16 CORRIDOR PLANNING

During project development, several offsite corridors will be required to provide transportation and utility services to and from the project site. These include an access road, power line, water supply pipeline (an alternative if the White River Dam is not constructed by the state of Utah), and an oil pipeline to transport the product. The oil pipeline alternatives are discussed in Section 7.17, "Product Transport."

At this stage of development, the locations of most of the alternative corridors have been identified only in general terms. During engineering design, exact routes will be surveyed and specific information will be available for evaluating more fully the environmental impact of the corridors.

Many of the facilities can be located in joint corridors. By exercising care and judgment in selecting and developing joint corridors wherever possible, the project will be able to minimize offsite environmental impacts and achieve important economic savings.

7.16.1 SELECTION CRITERIA

The primary criteria considered in evaluating the alternative corridors are as follows:

- Technical considerations
  - Special engineering requirements
  - Timing
  - Capital costs
- Environmental considerations
  - Existing habitat or vegetation
  - Rare and endangered species

- Historic or archaeological sites
- Scenic sites or recreation areas

- Socioeconomic considerations
  - Population growth patterns in the region
  - Commuting time, distance, and general convenience
- Use of existing or joint corridors where possible

7.16.2 ACCESS HIGHWAYS

Two access highways were evaluated: the major highway corridor from the project site to Bonanza, Utah, and the corridor from Bonanza to Vernal.

7.16.2.1 Corridor from Project Site to Bonanza

Three alternative routes were proposed from the project site to Bonanza:

- Alternative 1. This route follows a new corridor running southwest from Bonanza and crosses the White River on the crest of the proposed new dam. It then swings east to connect with the plant site. This corridor requires the construction of a new highway approximately 11 miles long.

- Alternative 2. This route uses the existing Highway 45 corridor south from Bonanza. Initial improvements proposed for this route include resurfacing the first 2 miles south of Bonanza, improving the alignment from that point to the White River, using the existing bridge over the river, and upgrading approximately 5 miles of the road south of the river. Eventually a new bridge would probably be needed across the White River as traffic increased or if a dam that would inundate the present bridge were constructed downstream. This route is approximately 9 miles long.

- Alternative 3. This route uses the existing Highway 45 corridor for the first 2 miles south of Bonanza and then swings east, crossing the White River on a new bridge east of the existing bridge and landing on the west bank of Evacuation Creek. It then swings west to connect with the plant site. This route is approximately 10 miles long, and a new highway would have to be constructed along most of this corridor.

The three routes were evaluated in terms of technical, environmental, and socioeconomic factors, as discussed below.

Technical Considerations. Timing is important in highway corridor selection. Alternative 2 is the most probable alternative, considering timing and schedule for this project. Alternative 1 depends on the construction of the proposed White River dam. Alternate 3 requires new bridges across the White River and across Evacuation Creek; these would take 2 to 3 years to plan, design, and construct.

Environmental Considerations. It appears that Alternative 2 has the least environmental impact because it:

- Is the shortest
- Minimizes new cuts and surface damage, including attendant erosion, since it uses the existing highway
- Does not affect the habitat along the river, as no new river crossings are required
- Does not require bridge construction across Evacuation Creek

It is reasonable to assume that development along the existing highway (Alternative 2) would have less impact on threatened and endangered species, historic and archaeological sites, and recreation and scenic areas than would the development of new highways.

Socioeconomic Considerations. Virtually all highway travel to and from the project site is expected to use the selected corridor. Since Alternative 2 is the shortest corridor, it would save driving time and therefore fuel resources.

Use of Existing or Joint Corridors. Only Alternative 2 meets the criterion of using existing corridors where possible.

7.16.2.2 Corridor from Bonanza to Vernal

Three alternative routes between Bonanza and Vernal were proposed, as shown in Figure 7.16-1. These routes are:

- Alternative 1. This route is more direct than the existing unimproved road and power line. It requires a new bridge over the Green River southwest of Jensen, is approximately 37 miles long, and is the shortest of the proposed alternatives. Uintah County has decided to proceed with building this road. This will provide reduced travel time from Vernal, and will also provide two access routes to Bonanza.

- Alternative 2. This route follows existing U.S. Highway 40 to the Jensen Crossing of the Green River; it then proceeds along the southern bank of the Green River, using the existing SR-264 corridor until it intersects with proposed Alternative 1. It then follows Alternative 1 on to Bonanza. This route is approximately 42 miles long.

- Alternative 3. This route uses existing U.S. Highway 40 and Utah State Highway 45, including the necessary upgrading and improvements. The route is approximately 46 miles long.

Since Alternative 1 has been approved by Uintah County, no selection process is necessary.

Socioeconomic Considerations. Since a large portion of the highway traffic will be between Bonanza and Vernal, Alternative 1 provides the greatest savings in driving time and resources consumed by vehicles traveling this route. Alternative 3 is the least desirable from this point of view.

Use of Existing or Joint Corridors. All three alternatives make use of existing corridors.

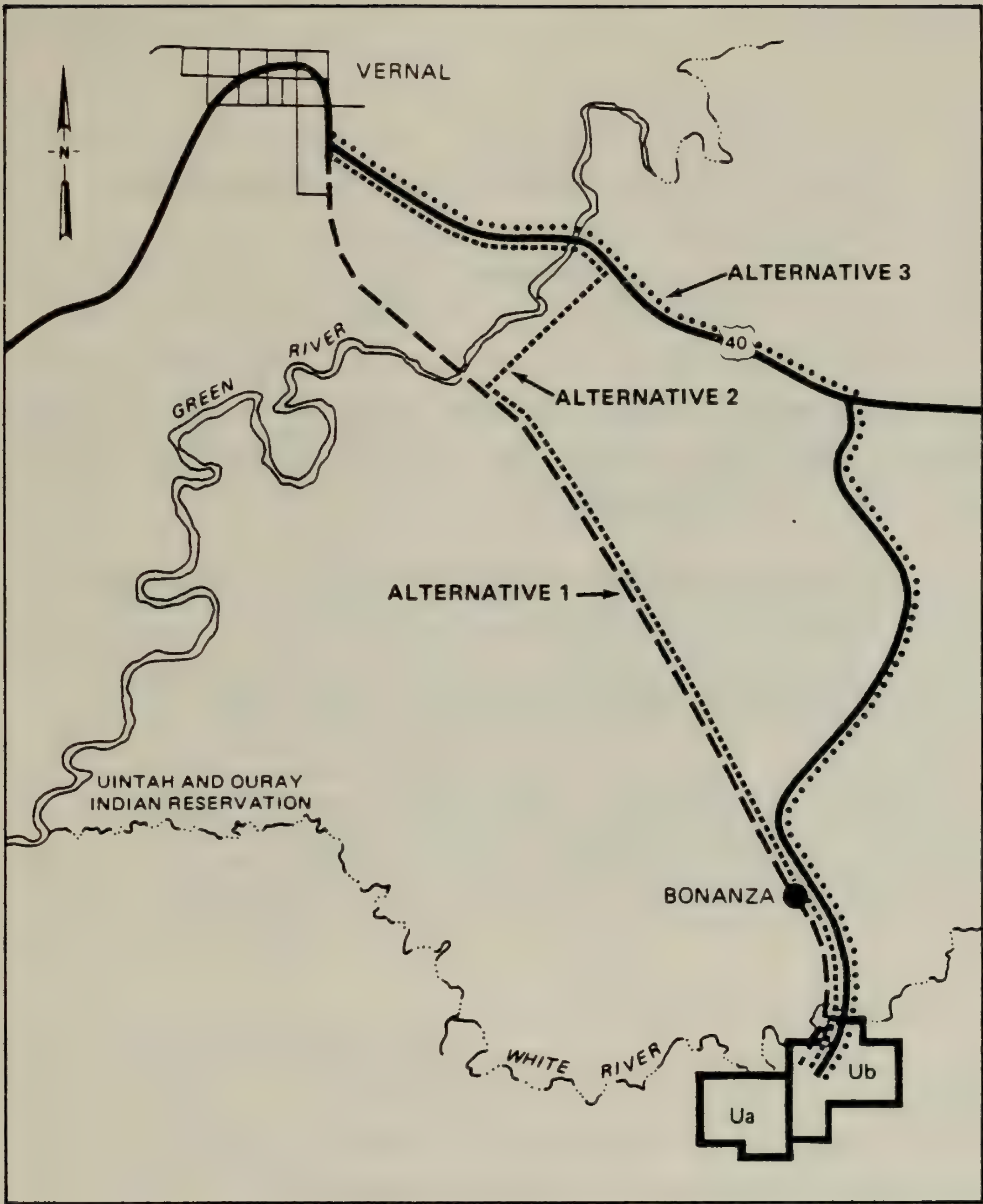

Figure 7.16-1 CORRIDORS FROM BONANZA TO VERNAL

7.16.3 POWER LINES

Initially, electric power for the project site will be provided by a new 69 or 138 kV transmission line from Bonanza. Moon Lake Electric Association, Inc. will supply this power and will construct the new line.

To provide adequate service from Bonanza to the project site, the power service into Bonanza will also have to be improved. Since this could be done by stringing new wire on the structures of an existing line from the Vernal area to Bonanza, a new power corridor between these two points would not be needed. Using this existing line would help reduce economic costs and minimize the environmental impacts.

The alternative corridors proposed between Bonanza and the project site are described below:

- Alternative 1. The power line follows the highway between Bonanza and the project site along the entire route.
- Alternative 2. The power line follows an existing 12 kV power line southeast from Bonanza along the approximate route of an existing pipeline. After crossing the White River, the line runs southwest for about 1 mile to the main access highway and follows this highway to the process facilities.

7.16.3.1 Technical Considerations

Since Alternative 1 is along the major access highway, the line would be easier to construct, maintain, and patrol. Alternative 2 requires a longer line, and the existing pole structures would have to be replaced since they were not designed to accommodate a higher voltage line.

7.16.3.2 Environmental Considerations

Locating the power line along existing or joint corridors should minimize the environmental impact on existing habitat, vegetation, and historic or

archaeological sites. The power line adjacent to the highway could obstruct scenic views along the route, particularly in the vicinity of the White River.

7.16.3.3 Use of Existing or Joint Corridors

Both alternatives make use of existing or joint corridors along most of the route and thus would minimize the impact of the power corridor.

7.16.4 WATER SUPPLY LINES

One alternative for supplying water to the project is to bring it from the Green River. Two routes have been proposed for this pipeline, as shown in Figure 7.16-2. These alternatives are described below:

- Alternative 1. This pipeline route takes water from the Green River at a point southeast of Vernal and follows an existing corridor in a southeastern direction to Bonanza. There is an existing unimproved road and power line along this corridor. From Bonanza, the pipeline follows the existing road to the project site, crossing the White River at the existing highway bridge.

- Alternative 2. This pipeline route takes water from the Green River at a point approximately 12 air miles southwest of the starting location for Alternative 1. This route runs easterly from the Green River and intersects Alternative 1 near its midpoint. The route is then the same as Alternative 1.

7.16.4.1 Technical Considerations

Since Alternative 2 is approximately 1-1/2 miles longer than Alternative 1 and takes water from the river at a lower elevation, its capital and annual pumping costs would probably be slightly higher. Furthermore, since part of Alternative 2 is located on the Uintah and Ouray Indian Reservation lands, approval would have to be secured from two agencies rather than from just the Bureau of Land Management, as in the case of Alternative 1. Construction time would be similar if the necessary approvals are secured.

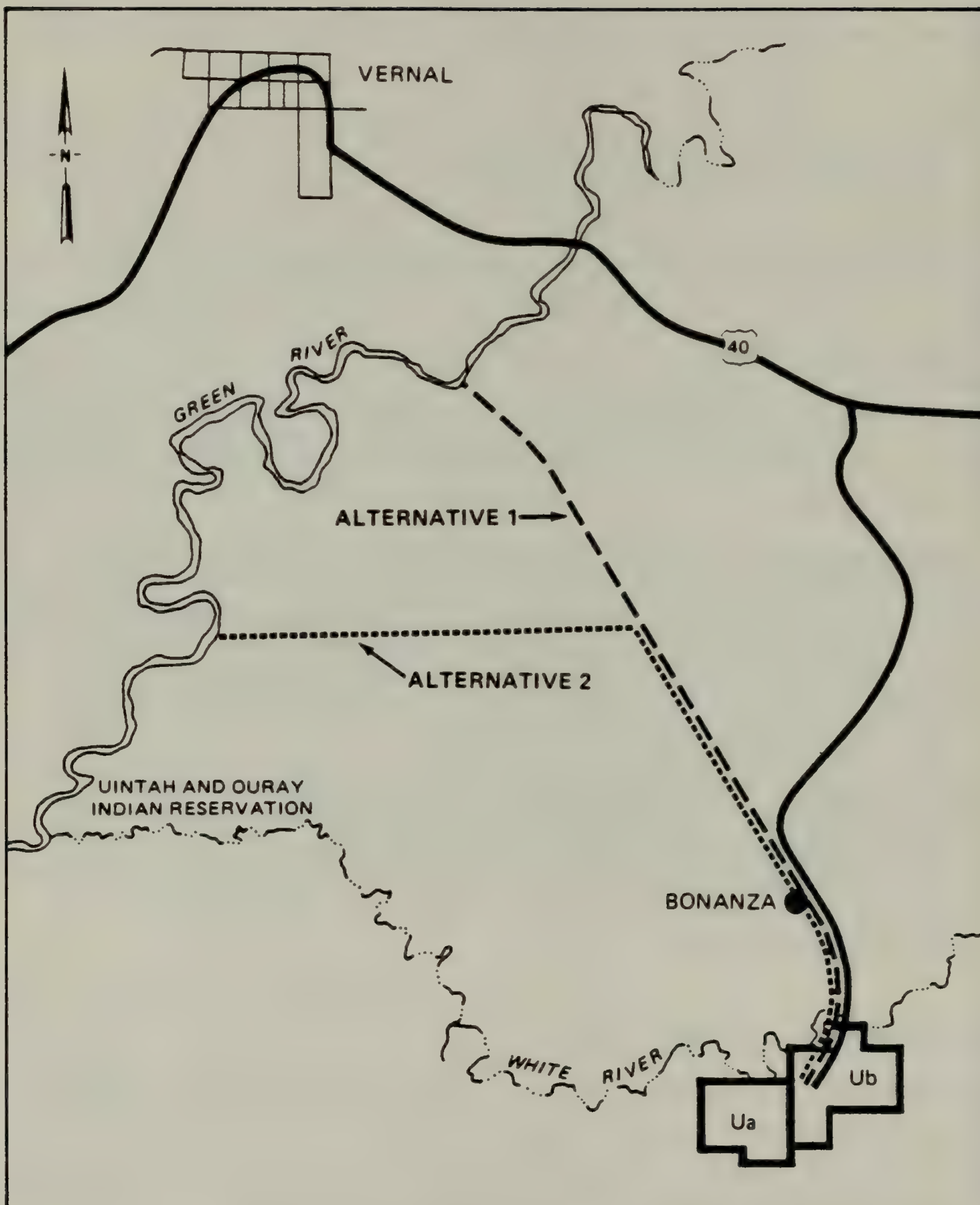

Figure 7.16-2 WATER SUPPLY ROUTES FROM GREEN RIVER

7.16.4.2 Environmental Considerations

Based on preliminary environmental surveys of these routes, the environmental tradeoffs are thought to be small since both routes traverse similar terrain. The use of existing corridors that include unimproved roads minimizes environmental damage during construction. With proper rehabilitation techniques, environmental impacts could be practically eliminated in a pipeline corridor. However, in the semiarid conditions found along both corridors, the return of vegetation to its natural state would take some time.

7.16.4.3 Use of Existing or Joint Corridors

Both routes would use existing corridors.

7.17 PRODUCT TRANSPORT

Several methods for transporting the shale oil product to markets were investigated. A pipeline, rather than unit trains, was found to be the most practical way to transport the shale oil, and this line should be ready for service for Phase II. During Phase I, the limited amount of shale oil produced would probably be transported to markets by tanker trucks.

Based on developments in the shale oil industry, there may develop alternative marketing, distribution, and refining centers. Alternative pipeline routes for raw shale oil may be considered.

Based on developments in the shale oil industry, there may develop alternative marketing, distribution, and refining centers. Alternative pipeline routes for raw shale oil may be considered.

7.17.1 ALTERNATIVE PIPELINE ROUTES

The proposed pipeline to Borger, Texas is based on the decision not to upgrade the raw shale oil on site. It was concluded that common carrier crude pipelines could not handle raw shale oil due to its highly viscous flow properties. If the shale oil is upgraded on site in the future, several other product transport alternatives become feasible. These alternatives involve the construction of a pipeline from Tracts Ua and Ub to a common carrier pipeline to Casper, Wyoming and Fort Laramie, Wyoming. These pipelines are described below and are illustrated in Figure 7.17-1.

- Alternative 1. This route runs from the project site to Casper, Wyoming. From the site to Colorado Highway 64, the line follows existing Bureau of Land Management corridors containing pipelines and roads. From Highway 64, the new pipeline follows an Amoco right-of-way containing a small-diameter crude line to Sunbeam, Colorado. From there, the line proceeds north to Wamsutter, Wyoming. From Wamsutter to Ferris, Wyoming the line follows an Amoco right-of-way containing a small-diameter crude line.

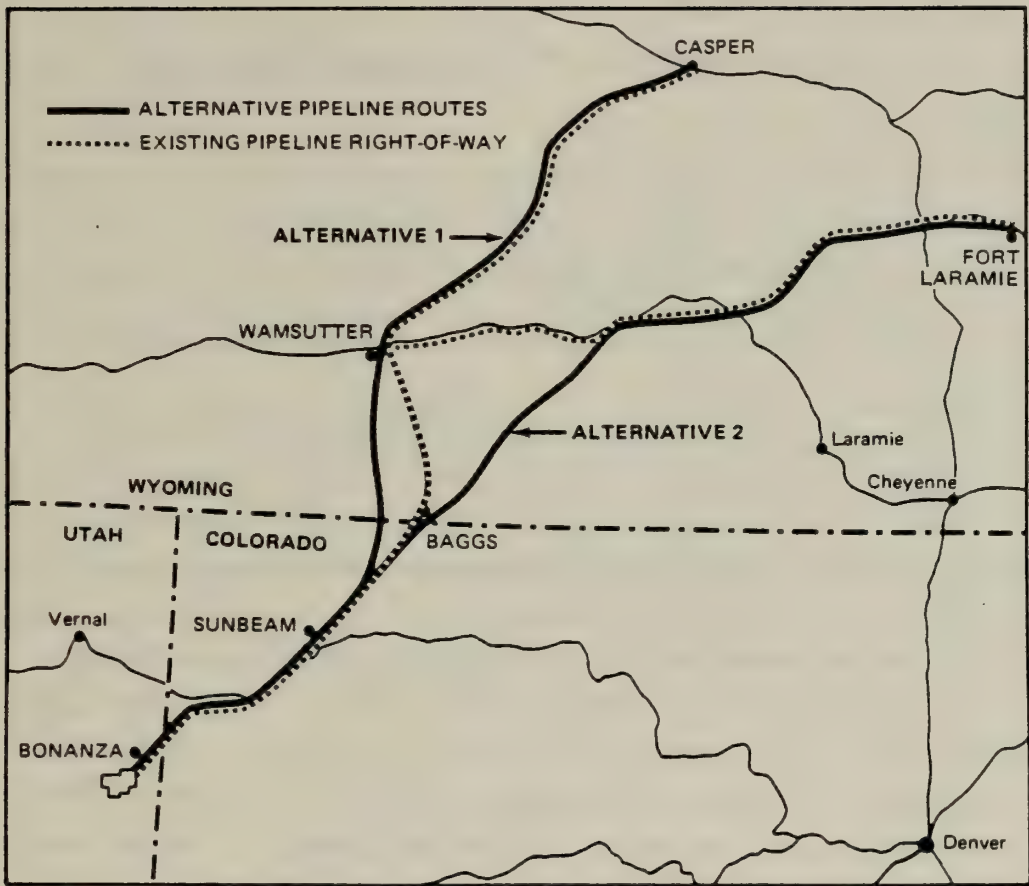

Figure 7.17-1 PIPELINE ROUTES FOR UPGRADED SHALE OIL

- Alternative 2. This route runs from the project site to Fort Laramie, Wyoming. From the site to Highway 64, the route is similar to Alternative 1. The line follows the Amoco right-of-way from Highway 64 to Baggs, Wyoming via Sunbeam, Colorado. It then follows a new corridor to Coyote Springs, where it follows another Amoco small-diameter crude pipeline to Fort Laramie.

7.17.1.1 Technical Considerations

The approximate distance in miles for the two alternatives is shown in Table 7.17-1.

Table 7.17-1

UPGRADED SHALE OIL PIPELINE DISTANCE
(miles)

Alternative	Existing Corridors	New Corridors	Total
1	200	80	280
2	237	85	322

Alternative 1 requires construction of the shortest pipeline. However, since Alternative 2 intersects the main crude carriers farther east, the overall transportation distances to the Midwest are shorter. Alternative 1 requires installation of additional pumping capacity from Casper to Fort Laramie. From Fort Laramie eastward, any changes needed in pumping capacity are the same for both alternatives.

Both alternatives require new rights-of-way along parts of their routes.

7.17.1.2 Environmental Considerations

No field reconnaissance of these alternative pipeline routes has been made, and topographical maps were used in judging terrain conditions. All of the

routes appear to traverse approximately the same type of terrain. No meaningful environmental tradeoffs were immediately evident between Alternatives 1 and 2.

7.17.2 ALTERNATIVE MARKETS FOR SHALE OIL

Two markets for the shale oil were also considered: Los Angeles Basin and Salt Lake Basin. The two markets are briefly described below.

7.17.2.1 Los Angeles Basin Market

This market would require a new pipeline from the project site south to the Four Corners area of Utah where connections could be made with pipelines serving the Los Angeles Basin. Shale oil from the WRSP would have to compete with North Slope crude from Alaska, which is currently destined for markets on the Pacific Coast, including the Los Angeles Basin.

7.17.2.2 Salt Lake Basin Market

This market would require a new pipeline from the project site to the Salt Lake Valley. There is an existing pipeline corridor between Rangely and Salt Lake City with small-diameter crude lines. The major problem is that the demand for crude oil and refining capacity in the Salt Lake Basin is limited, and the total output of the project probably could not be absorbed there.

7.18 BY-PRODUCT PLAN

This section discusses the by-products of alternative upgrading systems (described more fully in Section 7.8). The by-products are as follows:

- Coke
- Ammonia
- Claus sulfur
- Heavy unrefined oil
- Propane-propylene liquefied petroleum gas (C_3 -C_3 $^{=}$LPG)
- Surplus gas and/or power

The type of by-products depends on the upgrading procedure employed, as shown in Table 7.18-1.

7.18.1 COKE

Coke is a by-product in only two of the eight upgrading alternatives discussed in Section 7.8.1. It can be burned in a utility plant to produce power. The coke may be marketable as a metallurgical coke or an electrode coke, or it can be burned directly in a boiler.

7.18.2 AMMONIA

Ammonia is a by-product in four of the eight upgrading alternatives. The ammonia produced may be sold as anhydrous liquid ammonia, which can be used as fertilizer. Ammonia requires storage facilities, a loading rack, and truck transport facilities.

7.18.3 SULFUR

The sulfur is produced as a marketable by-product if produced in Claus sulfur plant. The sulfur produced in a Stretford sulfur plant may or may not be marketable.

Table 7.18-1

BY-PRODUCTS OF UPGRADING ALTERNATIVES

Case No.	Upgrading Scheme[a]		Sulfur	Ammonia	Coke	Unrefined Heavy Oil	LPG	Surplus Gas or Power
1	None	Raw Shale Oil, No Upgrading	X					X
2	Mild	Visbreaking	X					X
3	Mild	Delayed Coking	X		X		X	X
4	Mild	Heavy Oil Cracking Hydrostabilization	X			X	X	X
5	Moderate	Hydrotreating	X	X				
6	Severe	Delayed Coking Hydrotreating	X	X	X			X
7	Severe	Severe Hydrotreating	X	X				
8	Severe	Heavy Oil Cracking Hydrotreating	X	X		X		X

(a) See Section 7.8, "Upgrading."

7.18.4 SURPLUS GAS OR POWER

Surplus gas or surplus electric power is produced in all alternatives discussed except for hydrotreating. The surplus gas can be burned as a fuel on the tract; it can be converted to electric power in a utility plant on the tract; it can be sold to an adjacent utility plant; or it can be incinerated or vented on the tract. The amount of surplus gas and electric power produced for each alternative depends on the processing and electrical generation options employed.

7.18.5 HEAVY UNREFINED OIL

Heavy unrefined oil is a by-product of heavy oil cracking processes. This oil could probably be burned in a utility plant; it can be sold as a specialty product, or it can be sold to refineries in the area.

7.18.6 LIQUEFIED PETROLEUM GAS (LPG)

The by-product C_3 - C_3 $^{=}$LPG is an olefinic gas that meets the LPG specification for sulfur content and dryness. It may be sold as a specialty product because it contains propylene, possibly useful as a chemical raw material. Like ammonia, this LPG requires storage facilities, a loading rack, and truck transport facilities.

7.19 CONSTRUCTION PLAN

This section addresses the alternative selection of a construction campsite to cover the construction involved in the three phases of the project. It includes a discussion of the pertinent aspects of the alternative location, its access, and the selection rationale employed. The construction plan selected as part of the probable development plan is described in Section 3.19.

7.19.1 ALTERNATIVE SCHEDULES

The plans and schedules for construction of Phase I and the staged building of Phases II and III are the same as cited in Section 3.19 and presented in Figure 3.19-1. No changes that would affect the schedules associated with the most probable plan have been contemplated.

7.19.2 ALTERNATIVE CAMPSITE

The alternative campsite to the one selected for the most probable plan is an on-tract site located on the east-central extreme of Tract Ub. It comprises approximately 160 acres (1/4 of a section) of land at the location shown in Figure 7.19-1. The terrain involved is at an altitude of approximately 5,500 feet, and portions are hilly. The size of this plot is sufficient to provide for construction campsite needs during all phases of the project. This can be managed through properly planned expansion of the camp and its facilities to accommodate 75 percent of the maximum work force as it increases to the expected peak level of 4,000. The capacity and description of facilities within the camp, at this stage of planning, should not differ materially from that described in Section 3.19.

7.19.3 ACCESS

Access to the area is by Utah Route 45 (See Figure 7.19-1), which extends south from Bonanza across the White River and Evacuation Creek. State Highway 45 should be paved and improved by the time of any potential use

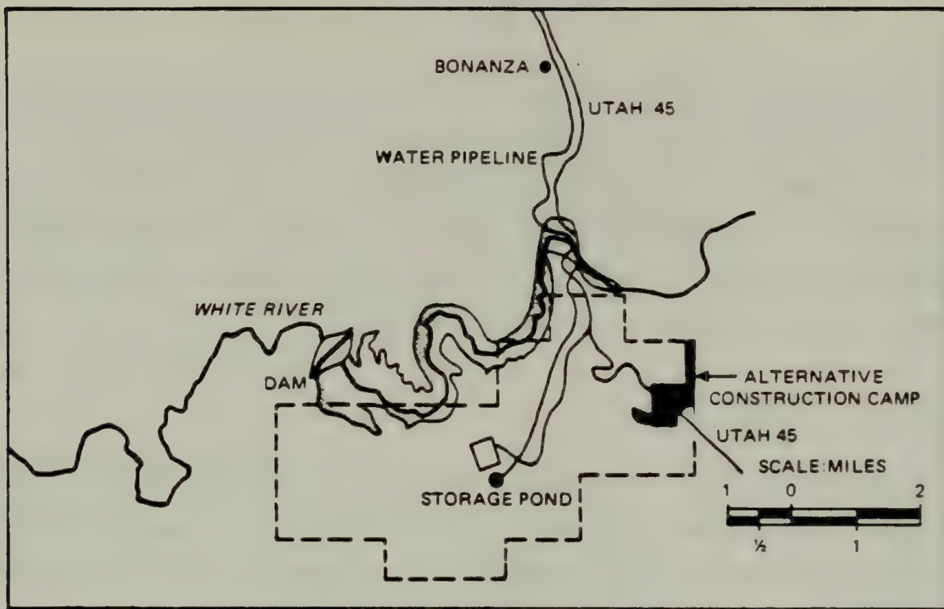

Figure 7.19-1 ALTERNATIVE CAMPSITE IN BONANZA

of the alternative campsite on Tract Ub. Discussions have been held with the Utah Department of Transportation, the Bureau of Land Management, and with the Uintah County Commission regarding alternative routes for an access road from Bonanza to the proposed plant site.

7.19.4 ALTERNATIVE EVALUATION

The federal lease terms of both Ua and Ub provide for use of the land for construction campsites, subject to the normal approval procedures set forth in the document covering land-use permits. With regard to accessibility of utilities, the location on Tract Ub is about equivalent to the off-tract preferred location described in Section 3.19. Access to the property is judged to be also nearly equivalent, except that the Ub location is closer to the construction area. Impact on the environment is also expected to be about the same regardless of location, since the same number of people would be involved.

7.19.5 SELECTION RATIONALE

The rationale for preferring the off-tract location to the Ub site is as follows:

- Environmental, utility, sanitary, and other factors associated with a construction campsite are about similar
- Access from the campsite to larger community facilities, such as shopping and entertainment favors the off-tract location
- The terrain is more level on the off-tract site than the Ub site. In an equivalent area, the off-tract site contains more usable ground for the camp, its facilities, and recreation needs

REFERENCES — SECTION 7

7-1 WRSP Preliminary Rock Mechanics Report, Cleveland-Cliffs Iron Company, Western Division, Rifle, Colorado, October 2, 1975.

7-2 Research and Development Program on the Disposal of Retorted Oil Shale, Woodward-Clyde Consultants, Denver, Colorado.

7-3 WRSP Water Supply Alternatives, Bingham Engineering, Bountiful, Utah, January 1976, p. 2.14-1.

7-4 Alternative Sources of Water for Prototype Oil Shale Development, Colorado and Utah, U.S. Water and Power Resources Service, September 1974 (draft).

7-5 U.S. Geological Survey Report, WSP No. 1886.

ABBREVIATIONS

AASHO	American Association of State Highway Officials
AMS	American Meteorological Society
AN/FO	Ammonium nitrate — fuel oil
ANSI	American National Standards Institute
AOSO	Area Oil Shale Office
AOSS	Area Oil Shale Supervisor
APCA	Air Pollution Control Association
°API	Degrees American Petroleum Institute
ASTM	American Society for Testing and Materials
AUM	Animal unit month
BACT	Best Available Control Technology
Bbl	Barrel
BPD	Barrels per day
BPCD	Barrels per calendar day
BPSD	Barrels per stream day
Btu	British thermal unit
C	Celsius
CEC	Cation exchange capacity
cfm	Cubic feet per minute
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cm	Centimeter
cms	Cubic meters per second
CO	Carbon monoxide
CS	Centistokes
dBA	A-weighted decibels
DDP	Detailed Development Plan

DH	Direct-heated
DOC	Dissolved organic carbon
EC	Electrical conductivity
EP	End point
EPA	Environmental Protection Agency
F	Fahrenheit
ft	Foot
ft^3	Cubic foot
gal	Gallons
gpd	Gallons per day
gpm	Gallons per minute
gpt	Gallons per ton
g/m^2	Grams per square meter
g/sec	Grams per second
ha-m	Hectare-meter
HC	Hydrocarbons
HHV	High heating value
hr	Hour
H_2S	Hydrogen sulfide
IBP	Initial boiling point
IH	Indirect-heated
JTU	Jackson turbidity unit
K	Kelvin
Km	Kilometer
kV	Kilovolt
kW	Kilowatt
lb	Pound
lb/day	Pounds per day
lb/hr	Pounds per hour
L_{dn}	Day-night sound level
L_{eq}	Equivalent sound level
L_n	Cumulative distribution level

LPG	Liquefied petroleum gas
ly/min	Langleys per minute
m	Meter
M	Thousand
mb	Millibar
mg/l	Milligrams per liter
mg/m^3	Milligrams per cubic meter
ml	Millileter
mm	Millimeter
MM	Million
m/sec	Meters per second
m^3/sec	Cubic meters per second
mmhos/cm	Millimhos per centimeter
mph	Miles per hour
mR	Milliroentgen
MSHA	Mining Safety and Health Act (Administration)
MSL	Mean sea level
MST	Mountain Standard Time
MW	Megawatt
MWHSD	Megawatt-hour per stream day
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
ng/m^2	Nanograms per square meter
NMHC	Nonmethane hydrocarbons
NOAA	National Oceanographic and Atmospheric Administration
NO_x	Oxides of nitrogen
NO_2	Nitrogen dioxide
NPDES	National Pollutant Discharge Elimination System
NSPS	New Source Performance Standards
NTU	Nephelometric turbidity unit
O_3	Ozone
OSEAP	Oil Shale Environmental Advisory Panel

OSHA	Occupational Safety and Health Administration
pCi/g	Pico Curie per gram
pCi/l	Pico Curie per liter
PC/l	Pico Curie per liter
PCU	Platinum cobalt unit
PDP	Preliminary Development Plan
POM	Polycyclic organic matter
ppm	Parts per million
ppmV	Parts per million volume
PSD	Prevention of Significant Deterioration
psi	Pounds per square inch
psia	Pounds per square inch absolute
psig	Pounds per square inch gauge
PVA	Polyvinyl acetate
RCRA	Resource Conservation and Recovery Act
ROW	Rights-of-way
SBR	Styrene butadiene rubber
SCFM	Standard cubic feet per minute
SCFSD	Standard cubic feet per stream day
SD	Stream day
SO_2	Sulfur dioxide
SPL	Sound pressure level
TDS	Total dissolved solids
TPD	Tons per day
TPH	Tons per hour
TPSD	Tons per stream day
TSP	Total suspended particulates
UBAQ	Utah Bureau of Air Quality
UOSHA	Utah Office of Safety and Health Administration
USGS	United States Geological Survey
UTM	Universal transverse mercator
vol %	Volume percent
WEA	Western Environmental Associates
WPRS	Water and Power Resources Service

WRSP	White River Shale Project
wt %	Weight percent
yd^3	Cubic yards
μ	Micron
$\mu g/l$	Micrograms per liter
$\mu g/m^3$	Micrograms per cubic meter
$\mu mhos/cm$	Micromhos per centimeter
σ_θ	Standard deviation of wind direction
σ_y	Standard deviation of crosswind direction
σ_z	Standard deviation of vertical wind direction

GLOSSARY

Abandonment. A relinquishment or a termination of the lease and no sale to another party of the permanent improvements.

Acid Gas. The hydrogen sulfide and carbon dioxide found in natural and refinery gases which, when combined with moisture form acides; these are known as sour acids when hydrogen sulfide or mercaptans are present.

Acre-foot. A volume that would cover one acre to the depth of one foot (325,850 gallons). One acre-foot per year equals 0.62 gallon per minute.

Alluvium. Clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent geologic time by running water.

Amine. One of a class of organic compounds which can be considered to be derived from ammonia by replacement of one or more hydrogen atoms by organic radicals.

Amine gas-treating unit. A unit that absorbs and removes acid gas from product gas by contacting the product gas with an aqueous solution of amine.

Aquifer. A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Artesian. Confined; and used to describe a well in which the water level stands above the top of the aquifer tapped by a well. A flowing artesian well is one in which the water level is above the land surface.

Baseflow. Sustained or fair-weather flow of a stream, whether or not it is affected by the works of man.

Berm. A narrow shelf, path, or ledge typically at the top or bottom of a slope.

Biota. The collective flora and fauna of any particular area.

Bottoms. Oil, water, and foreign matter that collects in the bottom of storage tanks.

C_5^+ Shale oil. Components of shale oil and gas with five or more carbon atoms per molecule.

Catchment. (See "Phase I retention dam.")

Centroid. (See "oil shale deposit centroid.")

Channery. Soils that contain fragments of flat sandstone, limestone, or schist up to 6 inches along the long axis.

Claus sulfur plant. A plant that converts hydrogen sulfide in a gas stream into elemetnal sulfur by means of solid catalysts.

Coke. A coherent, cellular, solid residue remaining from the destructive distillation of a coking coal, petroleum, or other carbonaceous material.

Coking. Destructive distillation of coal to make coke; a process for thermally converting the heavy residual bottoms of crude oil to lower-boiling-point petroleum products and by-product petroleum coke (thermal cracking for the conversion of heavy, low-grade oils into lighter products and a residue of coke).

Cracking. Conversion of high-boiling-point (high molecular weight) hydrocarbons into lower-boiling-point (lower molecular weight) hydrocarbons.

Cryptogam. Non-seed-forming plant, such as fungi, lichen, and moss.

Cubic foot per second. The rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second and is equivalent to approximately 7.48 gallons per second or 448.8 gallons per minute or 0.02832 cubic meters per second.

Cut-and-fill. A process for leveling land (to build roads, etc.) in which higher elevation land is removed and placed in lower elevation land to create a flat surface.

Dawsonite. A mineral consisting of a basic aluminum sodium carbonate.

Decibel. A unit for measuring the relative loudness of sounds and approximately equal to the smallest degree of different loudness ordinarily detectable by the human ear. The range includes about 130 decibels on a scale beginning with 1 for the faintest audible sound.

Decommissioning. The suspension by the lessee of the work programs or the further processing of shale, without dismantling or destroying improvements.

Direct-heated mode. A method of imparting heat to the shale by direct contact heat transfer with gases formed in a combustion zone inside a retort.

Dimictic. Temperate zone lake with spring and fall turnover.

Discharge. The volume of water (or more broadly, total fluids plus suspended sediment) that passes a given point within a given period of time.

Mean discharge is the arithmetic mean of individual daily mean discharges during a specific period.

Instantaneous discharge is the discharge at a particular instant of time.

Dissolved. Material in a representative water sample that passes through a 0.45-micrometer membrane filter. This is a convenient operational definition used by federal agencies that collect water data. Determinations of "dissolved" constituents are made on subsamples of the filtrate.

Drainage area. An area, measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a stream above a specified point.

Drainage basin. A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

Feed. Raw material that is fed into and processed in a unit.

Feed gas. Gas that is fed into and processed in a unit.

Fines. Smaller particles of oil shale coming out of the mine, or from the crushing operation. Fines are generally pea-sized and smaller (1/2-inch and under) and must be removed from the feed of certain retort systems.

Fischer assay. A tentative ASTM standard laboratory method for expressing the potential amount of oil able to be derived from shale by pyrolysis. The results are expressed as gallons of oil per ton of oil shale.

Flaggy. Soils that contain relatively thin fragments 6 to 15 inches long of sandstone, limestone, slate, or shale (or rarely schist). A single piece is a flagstone.

Flue gas. The gaseous product of the combustion of any fuel passed to the atmosphere through a stack, chimney, or vent.

Forb. An herb other than grass.

Fugitive dust. Colloidal-sized particulate matter generated incidentally by man's activities.

Gauge height. The water-surface elevation referred to some arbitrary gauge datum. Gauge height is often used interchangeably with the more general term "stage," although gauge height is more appropriate when used with a reading on a gauge.

Gauging station. A particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained.

Gas treating. Removing nonhydrocarbon impurities (such as ammonia, hydrogen sulfide, or carbon dioxide) from product gas.

Gilsonite. A black lustrous asphalt occurring especially in Utah (trademark).

High-Btu gas. A high-heating-value gas. The product gas from indirect-heated retorting is a high-Btu gas.

Hundred-year flood. The maximum flood that can be expected in a 100-year period.

Hydrocarbon. An organic compound containing only carbon and hydrogen.

Hyrotreating. An oil refinery catalytic process in which hydrogen is contacted with petroleum intermediates or product streams to remove impurities, such as oxygen, sulfur, nitrogen, or unsaturated hydrocarbons.

Hydrostabilization. A mild hydrotreating process that uses less hydrogen than hydrotreating.

Indirect heated mode. A method of imparting heat to the shale by an externally heated circulating gas stream.

In situ. Derived from the Latin term meaning "in place." With reference to oil shale, it describes a method of underground retorting whereby the oil is recovered and the shale residue is left in the ground.

Kerogen. The organic portion of oil shale. It decomposes when heated (to about 900F) to form synthetic oil and gaseous products.

Leachate. A solution or product obtained by leaching.

Light ends. The lower-boiling-point components of a mixture of hydrocarbons, such as those evaporated or distilled off easily in comparison with the bulk of the mixture; for hydrocarbon mixtures, this is usually considered to be butane or lighter.

Loam. Textured class name for soils having 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Low-Btu gas. A gas with a low heating value. The product gas from direct-heated retorting is a low-Btu gas.

Marlstone. A rock consisting of approximately equal amounts of carbonate and clay. Oil shale is basically a marlstone.

Micrograms per liter. A unit expressing the concentration of chemical constituents in solution as mass (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

Milligrams per liter. A unit for expressing the concentration of chemical constituents in solution. Milligrams per liter represents the mass of solute per unit volume (liter) of water. Concentration of suspended sediment also is expressed in mg/l and is based on the mass of sediment per liter of water-sediment mixture.

Mining panel. In the room-and-pillar method, a large area in the mine in which many pillars are left to support the roof.

Nahcolite. The mineral sodium bicarbonate. It is potentially commercially valuable for removing sulfur from flue gases.

Oil shale. Laminated sedimentary rock deposits containing both mineral and organic matter, principally kerogen.

Oil shale deposit centroid. The center of mass of the oil shale, as determined by geological studies.

Oolitic. The quality of having small round bodies that have grown by external accumulation. Usually refers to a sedimentary rock.

Overburden. Nonresource-bearing strata overlying the oil shale.

Particulates. Solid materials generated by processes and emitted from a discrete source (see "fugitive dust").

Petroleum naphtha. A low-boiling-point range hydrocarbon liquid mixture.

Phase I. The phase during which two commercial-size retorts of IH and DH types, along with a working mine and ancillary facilities, are developed.

Phase II. The first of two commercial operation phases, where Phase I production capacity is increased by construction of additional retorts, expanded mining, and additional ancillary facilities.

Phase III. The second of two commercial operation phases which is characterized by further facilities construction and culminates in the ultimate production capacity of the project.

Phase I retention dam (catchment). A dam built during Phase I adjacent to the processed shale pile, the purpose of which is to intercept runoff and leachate from the Phase I processed shale pile.

Pour point. The lowest temperature (determined by laboratory procedure) at which a liquid hydrocarbon will remain fluid enough to be poured.

Pour point depressant. An additive that lowers the pour point of an oil.

Processed shale. The residue shale from the retorting operation. It is normally 80 to 85 percent by weight of the original oil shale material.

Product gas. The usable gas emitted from the direct heated or indirect heated retort during the retorting of shale oil.

Pyrolysis. Chemical change brought about by the action of heat, in the absence of combustion.

Raptor. A bird of prey.

Reforming. A general term used for various thermal or catalytic conversions of petroleum, such as cracking, polymerization, dehydration, and isomerization.

Retort. The pyrolysis kiln in which raw oil shale is retorted.

Retorting. The process in which the kerogen in oil shale is converted by heating to oil and gas.

Room and pillar. An underground mining technique in which a room is mined out and a pillar is left for mine support.

Room. The opening in a mine between pillars.

Sandy Loam. Soil of the sandy loam class that has 50 percent sand and less than 20 percent clay.

Shale oil. A viscous organic liquid product produced from retorting oil shale.

Slurry. A two-phase liquid-solid mixture.

Solute. Any substance that is dissolved in water (or other solvent) forming a solution.

Sour gas. A gas mixture that contains hydrogen sulfide or mercaptans.

Sour water. Water containing hydrogen sulfide or mercaptans.

Sour water stripping. Removing hydrogen sulfide from sour water.

Southam Canyon retention dam. A dam built during Phase II at the mouth of Southam Canyon, the purpose of which is to intercept processed shale runoff and leachate and hence prevent them from reaching the White River.

Specific conductance. A measure of the ability to conduct an electrical current usually expressed in micromhos per centimeter at 25 degrees celsius. Specific conductance is related to the type and concentration of ions in solution and can be used for approximating the dissolved-solids concentration in water. Commonly, dissolved solids (in milligrams per liter) account for about 65 percent of the specific conductance (in micromhos) of common streams. The relation is not constant from stream to stream or from well to well, and it may even vary in the same source with changes in the composition or concentration of dissolved components.

Stope. An underground excavation from which the ore has been extracted, in a series of steps.

Storage silo. A circular vessel, usually having a conical bottom section, that is used for storing solids in bulk quantities.

Streamflow. The discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. Streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Stretford sulfur unit. A specific tradename plant that removes hydrogen sulfide in a gas stream and converts it to elemental sulfur.

Surge bin. A storage vessel that holds a sufficient volume of material to provide a steady supply to a downstream user or process.

Suspended sediment. The sediment that at any given time is maintained in suspension by turbulent currents or that exists in suspension as a colloid.

Suspended-sediment concentration. The velocity-weighted concentration of suspended sediment in a sampled zone from a stream at a point approximately 0.3 foot or 0.009 meter above the stream bed, expressed as milligrams of dry sediment per liter of water-sediment mixture.

Suspended-sediment discharge. The rate at which dry weight of sediment passes a section of a stream or the quantity of sediment, as measured by dry weight or volume, that passes a section in a given time.

Suspended-sediment load. The quantity of suspended sediment passing a section in a specified period.

Tail gas. Waste gas from a sulfur-treating plant.

Tail gas treating. Removing sulfur from tail gas.

Tank farm. An area containing large storage tanks for oil or other liquids.

Train. A processing system comprising a series of processing units.

Transect. A sample area (as of vegetation), usually in the form of a long continuous strip.

Tuff. A rock composed of the finer kinds of volcanic detritus, usually fused together by heat.

Turndown ratio. A measure of a unit's ability to operate at lower production capacity, expressed as the lowest capacity reasonably operable as a percent of the normal unit design capacity.

Two trains. Two parallel processing systems.

Upgrading. The various process combinations employed to improve the quality of the oil.

Vector. Any organism that is the carrier of a disease-producing virus or bacteria.

Visbreaking. A mild thermal cracking process that lowers the molecular weights of the hydrocarbon molecules only slightly.

Water bar. A ridge built across a road to divert runoff.

Wet scrubber. A vessel in which spray liquid is used to absorb solid particulates and remove them from circulating gases.